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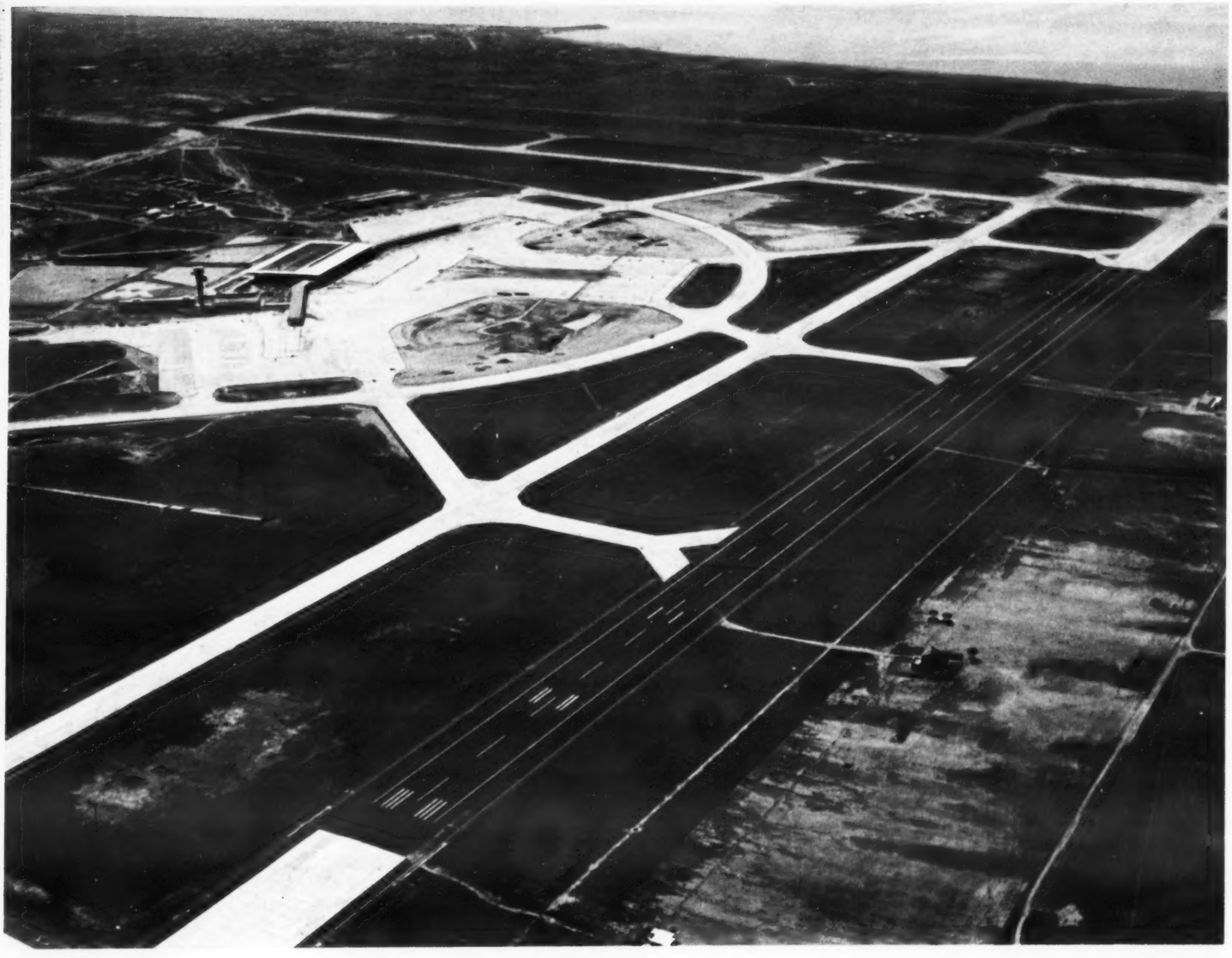
World Review of Aviation and Astronautics

with Electronics Supplement



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Volume XV

INTERAVIA

June 1960

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Front cover: Helicopter's-eye view of Rome-Fiumicino Leonardo da Vinci Intercontinental Airport, showing the full length of the east-west runway and about half the north-south runway. To the left, the terminal building with its two fingers, the control tower and the extensive apron; in the background the Tyrrhenian Sea *(Italian Air Force)*.

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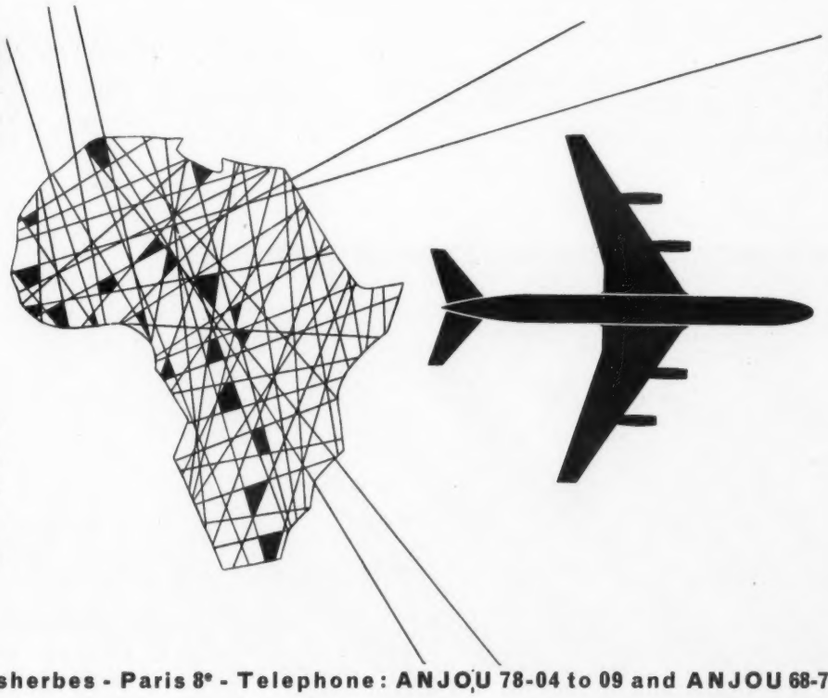

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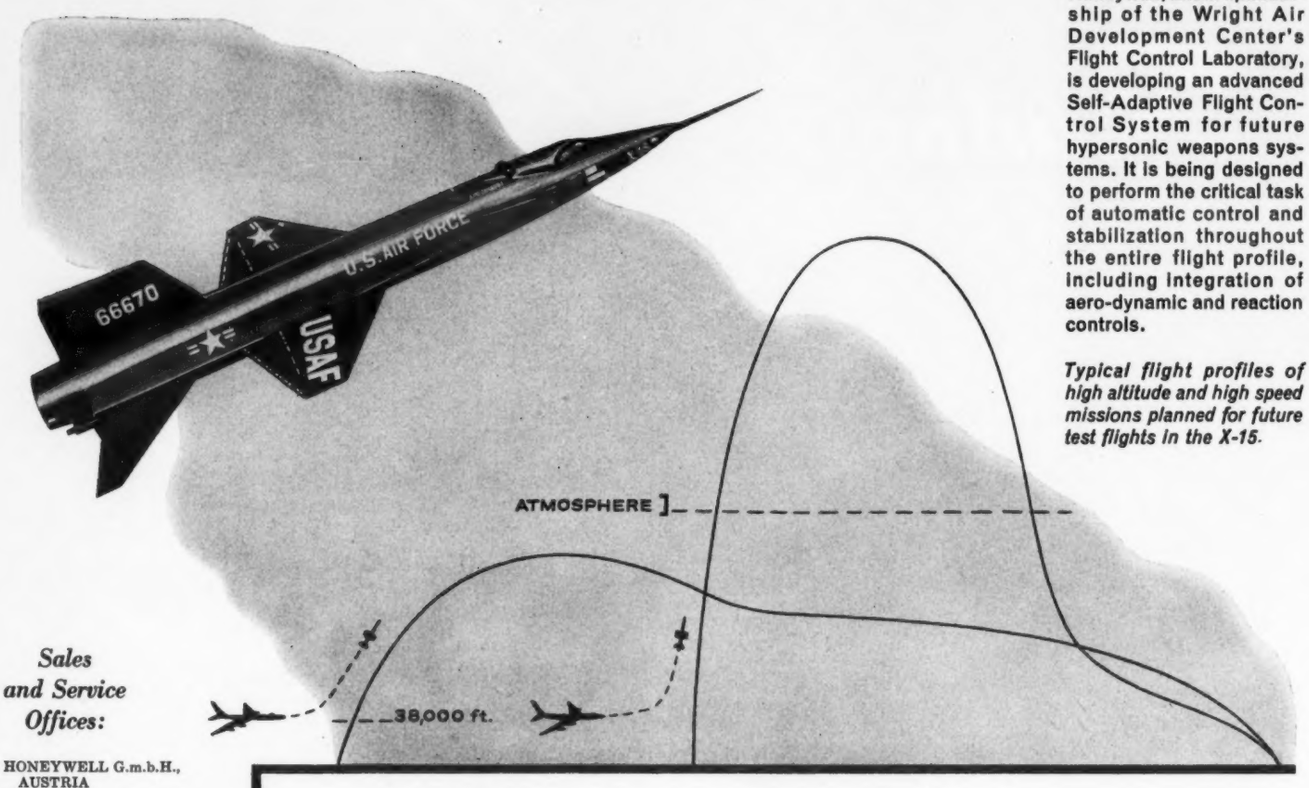

Honeywell, under sponsorship of the Wright Air Development Center's Flight Control Laboratory, is developing an advanced Self-Adaptive Flight Control System for future hypersonic weapons systems. It is being designed to perform the critical task of automatic control and stabilization throughout the entire flight profile, including integration of aero-dynamic and reaction controls.

Typical flight profiles of high altitude and high speed missions planned for future test flights in the X-15.

FROM SEA LEVEL TO SPACE

The Honeywell Self-Adaptive Autopilot is designed to deliver optimum performance for every type of flight vehicle

The simplest, most reliable automatic flight control system yet designed, the Honeywell Self-Adaptive Autopilot operates independently of air data information and complex gain scheduling. Adjusting itself in response to its own performance, it is unaffected by changes in aero-dynamic characteristics. Here are some of its advantages.

Simplicity—Needs no air data information for gain scheduling—is not significantly affected by design modifications in aircraft, asymmetric loading or center of gravity changes—is easily mechanized and needs little tailoring to specific vehicles—is 45% smaller and lighter—requires 50% less power.

Reliability—Provides major reduction in required components, sub-assemblies and wiring—uses solid state amplifiers and switching logics.

Economy—Assures significant cost reductions through low initial cost of design and development, and simplified logistics, training and maintenance.

Versatility—Can be quickly adapted without major modifications to business aircraft, helicopters, drones, supersonic fighters and bombers, missiles and the latest hypersonic research vehicles. The Honeywell Self-Adaptive Autopilot System is now undergoing flight tests in both the supersonic F101A and "light-twin" Cessna 310 aircraft—impressive evidence of its wide range of adaptability. To learn about fitting it into your plans, write Honeywell, International Division, Minneapolis 8, Minnesota, U.S.A.

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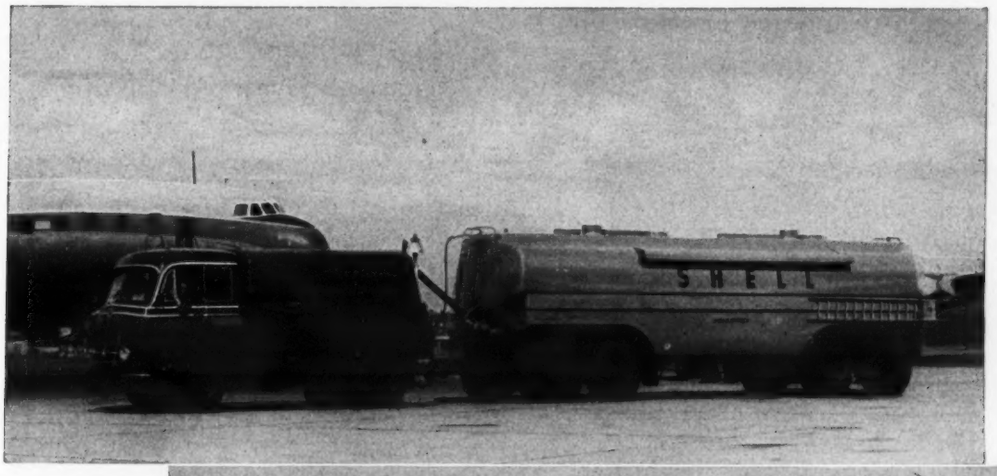

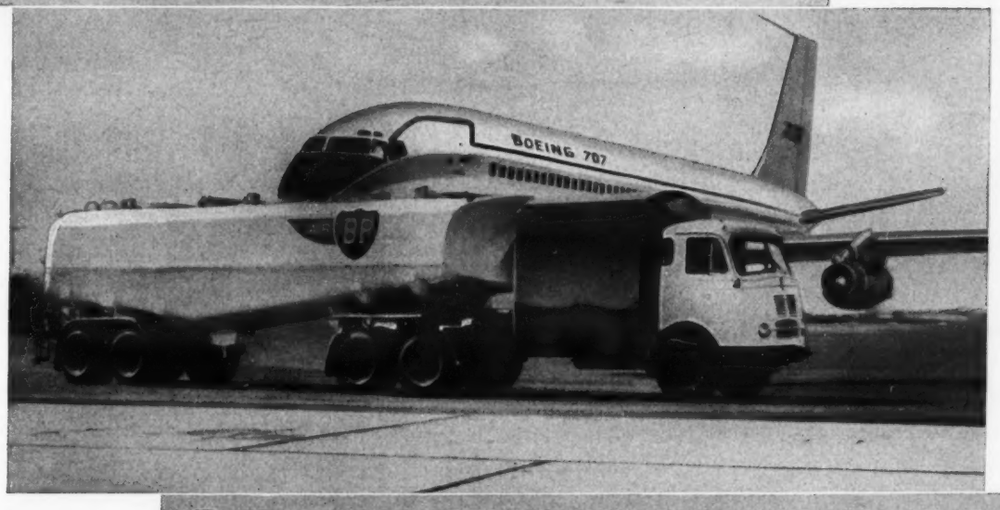

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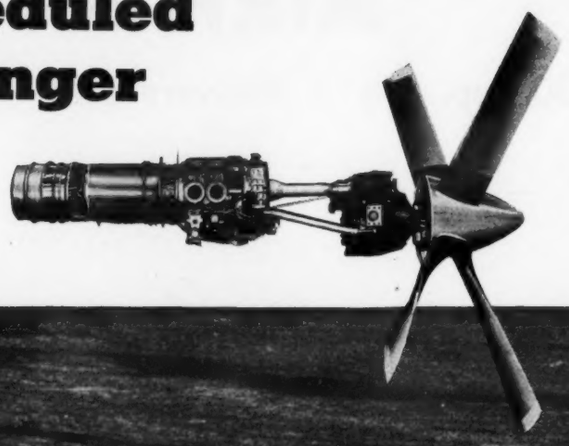
Allison Prop-Jet Convairs to begin scheduled airline passenger service



Allison 501 Prop-Jet engines develop 3750 h.p. and are approved by the FAA to fly 1000 hours before overhaul.

Late this summer the first U. S. scheduled airline will put Allison-powered prop-jet Convairs into service. This prop-jet aircraft is ideally suited for the routes of this local service carrier, Lake Central Airlines, where flight segments average just over one-hundred miles.

Standard Convair 340/440 aircraft, converted to Allison 501 prop-jet engines and Aeroproducts Turbo-Propellers, cruise at 350 miles per hour—the fastest twin-engine jetliner now in scheduled local service. The Prop-Jet Convair climbs to 20,000 feet from sea level in just thirteen minutes. Its short field performance is exceptional. Full payload range is 675 statute miles—a profitable 550 miles greater than piston-powered Convair 340s.

The Allison Prop-Jet Convairs, now fully certificated by the U. S. Federal Aviation Agency, offer airlines and corporate operators jet-age advantages at lowest initial cost—and even on the shortest flight segments. Route analysis of several airlines reveal this jet-age plane yields 19% to 48% return on invested capital.

Lake Central's purchase of five Allison Prop-Jet Convairs, with options on ten more, increase to 16 the number of firm orders for this speedy economical aircraft. This includes the following corporate operators who desire for their executives the same advantages of modern jet age, economical transportation: AC SPARK PLUG DIVISION OF GENERAL MOTORS • ALLISON DIVISION OF GENERAL MOTORS • FORD MOTOR COMPANY • HUMBLE OIL COMPANY • UNION OIL COMPANY.

ALLISON PROP-JET POWER

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GM JET POWER

Il y a 3 ans SOURIAU lançait sur le Marché Européen ce slogan !..

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COMPLETE FREEDOM OF DESIGN...

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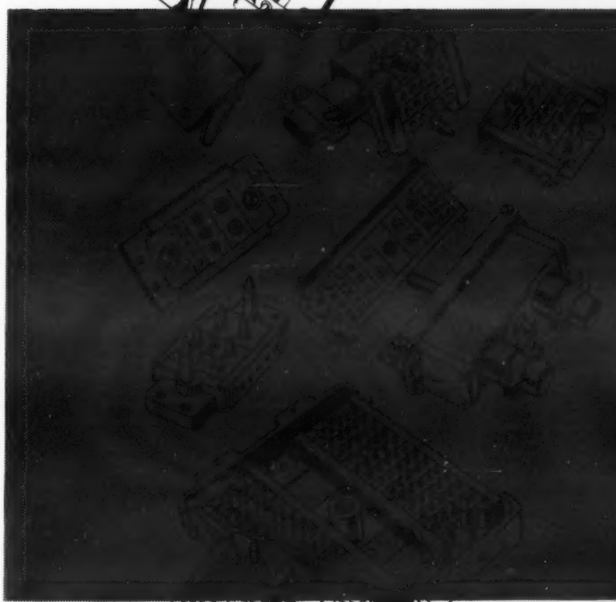
ALLE MÖGLICHKEITEN SIND GEGEBEN...

Nessuna servitu'
LIBERTÀ COMPLETA DI CONCEPIMENTO

Ya no servidumbres
COMPLETA LIBERTAD DE CONCEPTIÒN...

Il soulignait les nombreux avantages



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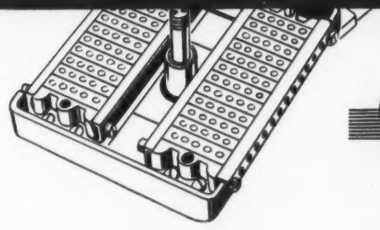

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To reflect our dynamic growth in such fields as electronics, missiles and space, automotive, weapons systems, computers, machine tools, instrumentation, nuclear technology, hydraulics, meteorology, electrical, marine and others, we are dropping "Aviation" from our corporate name on June 1, 1960. We do not wish to convey the impression that our products and skills are limited to the field of aviation alone, although aviation products accounted for billings of $388,700,000 in 1959.

Today Bendix—through 25 divisions and 16 subsidiary and affiliate companies around the world—serves many fields.

Our success in the rapidly expanding age of aviation has long obscured the fact that the Bendix® automobile starter drive was the company's first major product. Bendix introduced the type of four-wheel brakes that over the years has been used on most makes of cars. Bendix also pioneered automotive power brakes and power steering. Our automotive business in 1959 totaled $114,300,000.

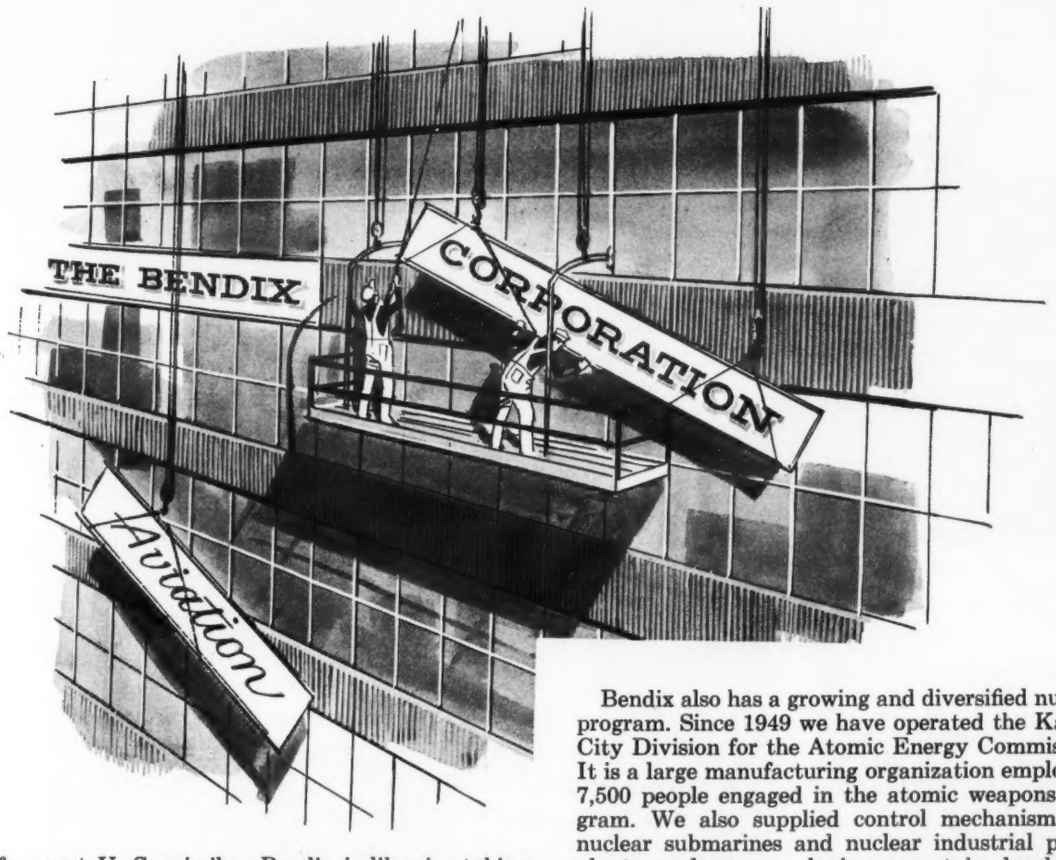
A notable trend in Bendix' recent history is the utilization of electronics in many of our major fields of activity. These range from automobile radios to aircraft and industrial communications and automatic flight controls . . . from electronic computers and data processing to numerical tape control systems for machine tools . . . and from transistors and ship-to-shore telephones to sonic cleaning and undersea sonar detection equipment. Approximately 40% of Bendix products are electronic, including air defense radar which today guards 25 million square miles of the earth's surface.

Missile and space equipment accounted for $103,000,000 of our total business of $689,692,312 in 1959. In addition to being the prime contractor for two important missiles, Talos and Eagle, we are also a supplier of components and sub-systems

diversification as Bendix Aviation Corporation . . .

our name to

Corporation



for most U. S. missiles. Bendix is likewise taking an active part in Project Mercury and in satellite communications. The first is the program to put a man into space. The second will mark a new era in communications by using a satellite in orbit as a relay station for global radio messages between earth stations and aircraft.

Bendix also has a growing and diversified nuclear program. Since 1949 we have operated the Kansas City Division for the Atomic Energy Commission. It is a large manufacturing organization employing 7,500 people engaged in the atomic weapons program. We also supplied control mechanisms for nuclear submarines and nuclear industrial power plants, and we are playing a part in developing the newest U. S. atomic power plants for aircraft, missiles and space vehicles.

Thus, as we drop "Aviation" from our corporate name, but not from our programs, we face a tomorrow where the range of our opportunities is broadening at a breathtaking rate.

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O.N.E.R.A. (Office National d'Etudes et de Recherches Aéronautiques) has designed and developed a complete VHF telemetry chain.

S.F.I.M. has now acquired the licence to manufacture this equipment. The firm studies, develops and produces its various component systems and operates the mobile receiver and recording stations on behalf of the users.

S.F.I.M. telemetry equipment is now in current use by the French Navy, the Government Flight Test Centre, G.A.M.D., Nord-Aviation, Sud-Aviation, etc., and has played its part in a number of comparative tests made by the automobile industry.

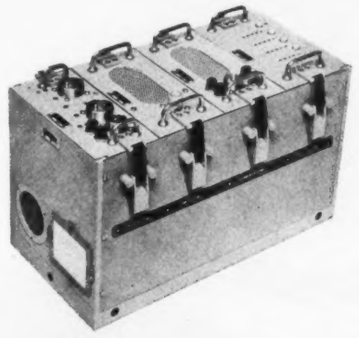
Main characteristics: 5 channels operating continuously and simultaneously.
Passing band: 400 c/s

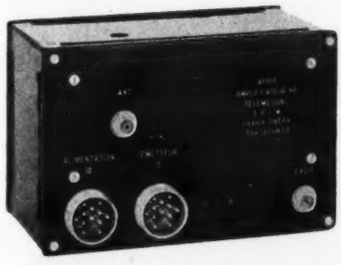
Frequency in the 100 Mc/s and 250 Mc/s bands.

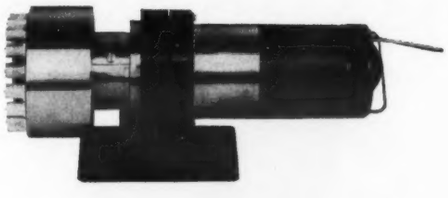
Component units:

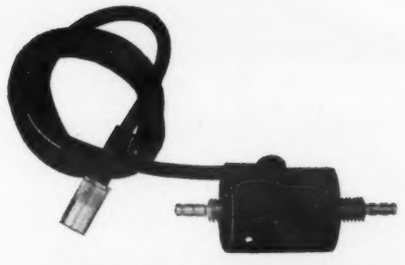
Airborne:
- 5-channel transmitter
- pick-ups for pressure, linear and angular movements, acceleration, temperature, galvanometric measurements
- 15-channel commutator, passing band per channel 10 c/s

On the ground:
- receiver
- control cabinet
- decoding cabinet
- photographic recorder









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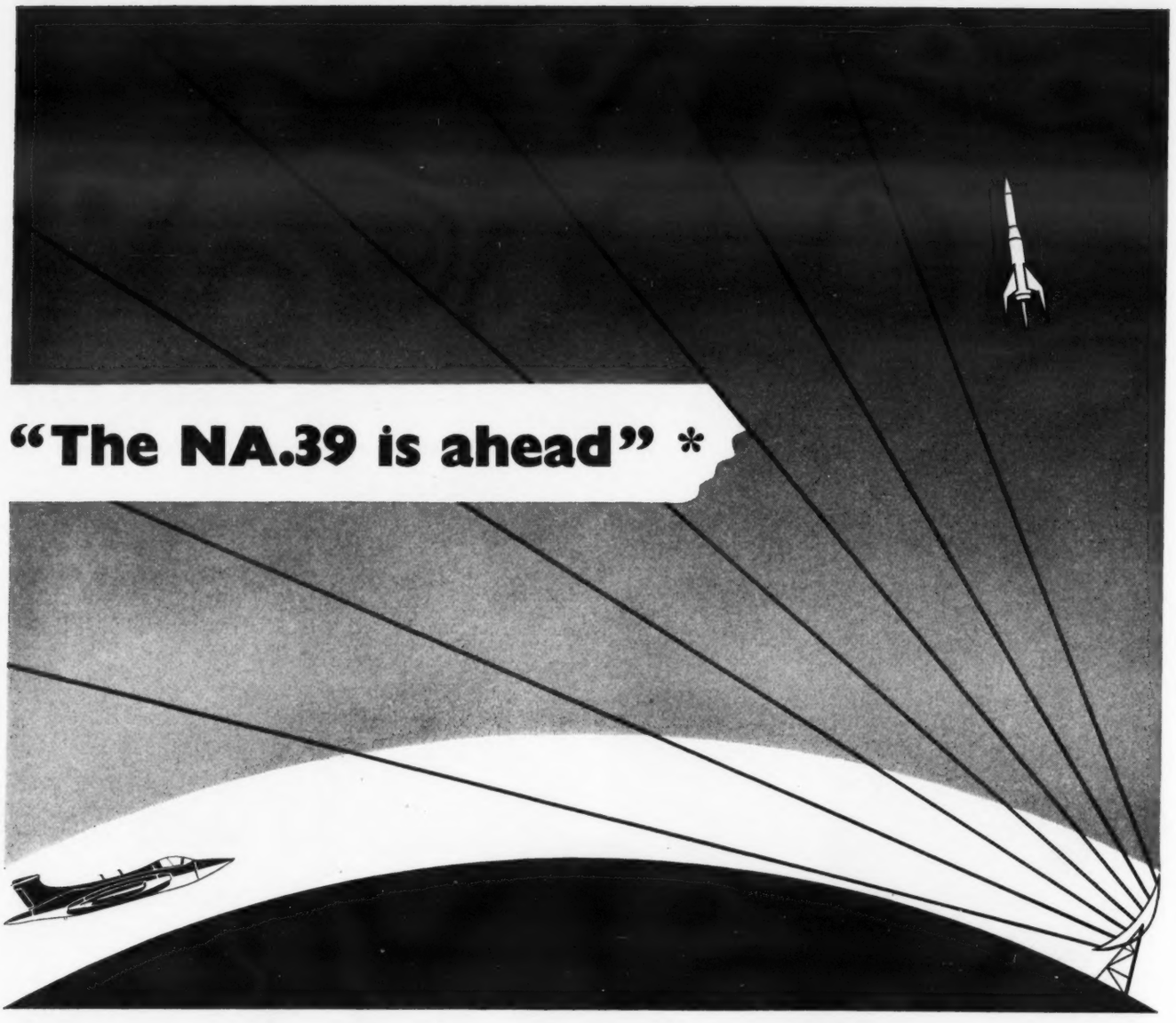
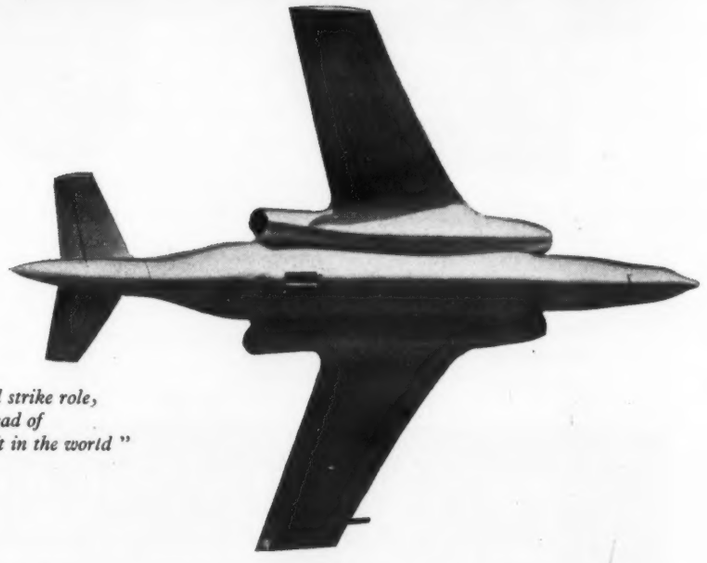


"The NA.39 is ahead" *

Today, in any major war, an enemy would be protected by an almost impenetrable curtain of radar and guided missiles. But there is a gap *beneath* the curtain; a vulnerable level.
The NA.39 is designed and constructed to strike at this vulnerable level and that is why the Ministry of Defence has stated—



* *"In the low-level strike role, the NA.39 is ahead of any other aircraft in the world"*

Blackburn

BLACKBURN AIRCRAFT LIMITED, BROUGH, YORKSHIRE, ENGLAND

SKY CHAMPION
Gear Grip

SKY CHAMPION
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The Records Prove Firestone
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Give You 8 to 11% More Landings Per Tire

In maintaining today's multi-million dollar planes successful airlines eliminate every unnecessary expense. That is why more and more of the new jets and high speed reciprocating-engine planes are being equipped with Firestone Sky Champion Aircraft tires.

Accurate records over several years by a major airline proved that Firestone tires and retreads outperformed all others by 8 to 11%.

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Firestone Aircraft tires are manufactured in the United States and Great Britain. New technical data books are available at no charge. See your Firestone Distributor or write to –

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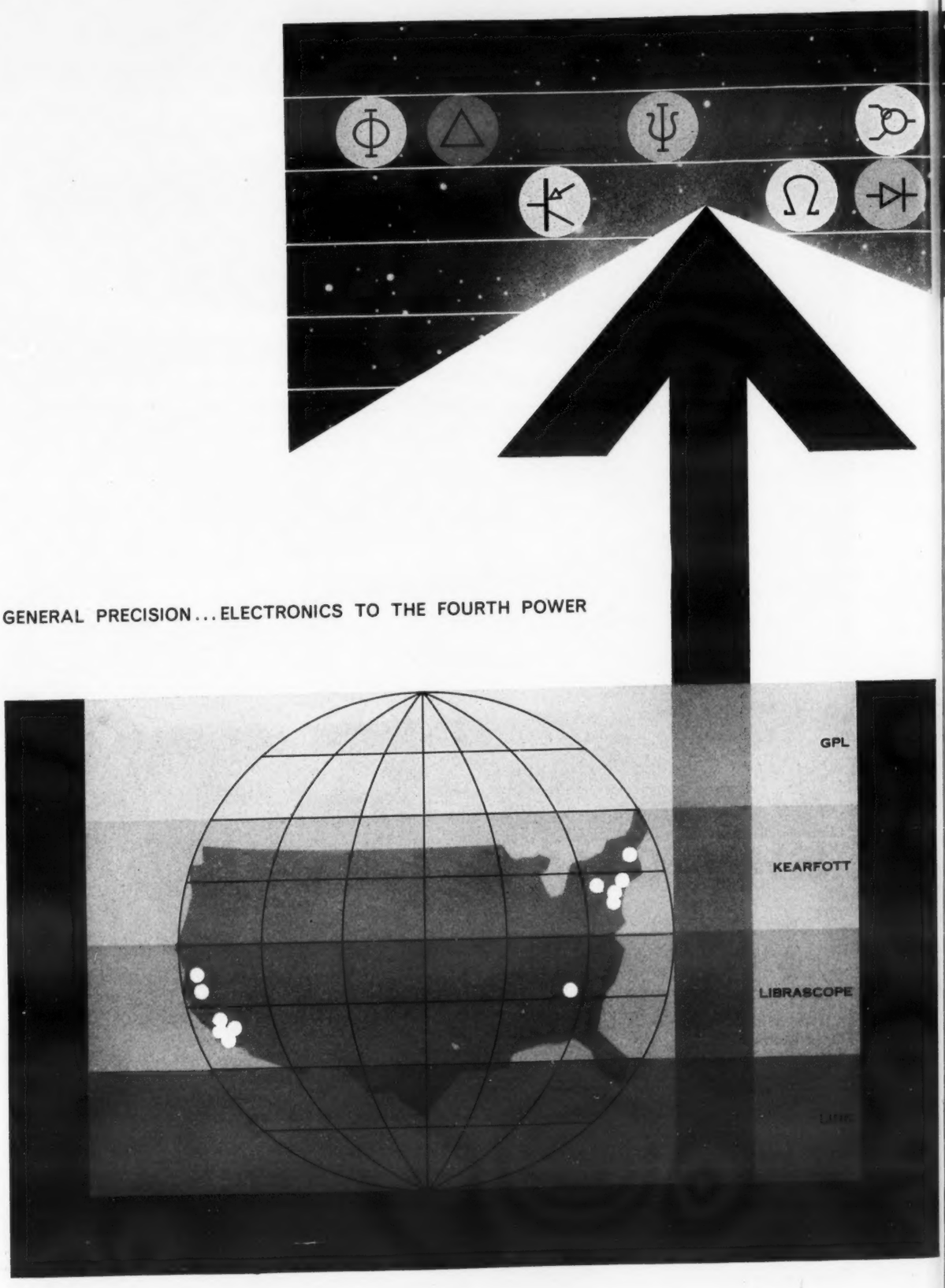
Firestone Tyre & Rubber Company Ltd., Brentford, Middlesex, England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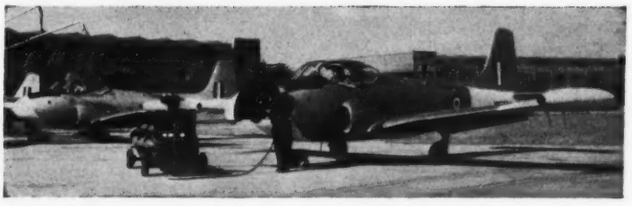
in service with the Royal Air Force



With pride we announce the continuing exclusive use of HUNTING designed and manufactured primary/basic trainers in the Royal Air Force.

After the most thorough evaluation ever given to any training aircraft, the Jet Provost T.Mk.3 (powered by the Bristol Siddeley Viper) is now in operation at Royal Air Force Basic Flying Training Schools.

Similar to the T.Mk.3 but fitted with armament in addition, the Jet Provost T.Mk.51 is in service with the Royal Ceylon Air Force.

HUNTING AIRCRAFT LIMITED

A Hunting Group Company

Luton Airport, Bedfordshire, England, and at 1450, O'Connor Drive, Toronto, Canada

The E. E. Heiman Prize

INTERAVIA

International Essay Competition

As announced in the January, 1960, issue, *Interavia* is holding an international contest to be known as the "E. E. Heiman Prize" in memory of its Founder and Editor-in-Chief. Three prizes, to the total value of

$ 3,000

will be awarded at the 24th Paris Air Show in 1961.

In order to encourage the development of aviation for peaceful purposes, *Interavia* has decided not to offer a prize for a military subject this time, but to concentrate on a question of topical interest in civil aviation:

What could be done during the next ten years to develop short-haul air transport (over distances of up to, say, 600 miles) from the technical and economic points of view?

In the past few years long-range air travel has not only overtaken surface travel in the number of passengers carried, but has also constantly generated new traffic. This trend can be expected to continue, in view of the substantial sums which world aviation has invested in expanding long- and medium-stage traffic. Short-haul air transport has also made great strides, but its place in short-distance travel, which accounts for the lion's share of total transportation business, still remains modest. In today's state of the art, however, short-haul aircraft should be able to carry passengers not only faster but also just as economically as surface means of transport. What ways and means—aircraft (VTOL, STOL, helicopters, etc.), airports, air traffic control, travel from city centre to city centre, cooperation with other means of transport, etc.—could be applied in order to multiply the share of air travel in the total short-distance transport market?

Competition Rules

- *Article 1*—The competition is open to all *Interavia* readers. Members of the *Interavia* management, editorial and administrative staffs, and their families are debarred from participating.
- *Article 2*—Manuscripts will be accepted in English, French, German or Spanish. They should not be longer than 3,000 words and must not have been published previously.
- *Article 3*—Manuscripts (in two typewritten copies) must reach the *Interavia* Secretariat, 6, rue de la Corraterie, Geneva, Switzerland, not later than 12 noon on December 31st, 1960. Handwritten manuscripts or manuscripts arriving after that date will not be considered.
- *Article 4*—The name of the author may not appear on the manuscript, which must be signed with a pseudonym. All manuscripts must be accompanied by a sealed envelope containing the author's full name and permanent address, marked on the outside with the pseudonym used. These envelopes will not be opened until the Panel has made its decision.
- *Article 5*—The composition of the Panel of Adjudicators will be announced shortly.
- *Article 6*—No correspondence can be entered into, nor any claims entertained, regarding the decision of the Adjudicating Panel, which is final.
- *Article 7*—The best essay will be awarded a cash prize of $1.500, the two runners-up cash prizes of $1,000 and $500 respectively.
- *Article 8*—*Interavia* reserves all rights for publication or translation of the prize-winning essays, without payment of fees. *Interavia* also reserves the right to publish non-prize-winning essays, under terms and conditions to be agreed with the author. *Interavia* does not, however, guarantee that prize-winning essays will be published.
- *Article 9*—If in the Panel's opinion no essay reaches the prize-winning standard, the prize money will be paid into a charity, to be selected by majority vote of the Panel.
- *Article 10*—The address given in the sealed envelope must be one at which the participant can be contacted at any time during the period of the contest.
- *Article 11*—Submission of a manuscript implies acceptance of the competition rules. *Interavia* can accept no liability for the loss of manuscripts, which will *not* be returned. The Geneva, Switzerland, civil courts are the only competent authority for the settlement of any disputes arising from the contest.

INTERAVIA S.A., Geneva

Additional announcements regarding the competition will be made from time to time in "Interavia, World Review of Aviation and Astronautics."

The U.S. Aircraft Industry at the Cross-Roads

BY SCOTT HERSHEY, NEW YORK

There was a sign of things to come or perhaps even of things gone by, when the Aircraft Industries Association, trade organization of the aircraft and related industries, after much soul-searching decided to change its name to Aerospace Industries Association. The group, incidentally, was once known as the Aeronautical Chamber of Commerce. But this is 1960.

And in 1960, only three of the venerable, but young in years, member aircraft companies were able to report an increased profit for the year before. The three included one which seemed unlikely to be in this select company not too many years ago, The Martin Company. The others, highly different in their methods and objectives, were North American Aviation and Grumman Aircraft Engineering Corporation. These three, individually, each had one of the best years in their histories. More of which later. What happened to the others ?

It is the story of aircraft manufacturers, or perhaps airframe manufacturers, told again and again. Take, for example, the case of Douglas, a name known and respected around the world. DC aircraft are known wherever an aircraft can land and in some unlikely places where nobody ever thought an aircraft could land and take off again. But Douglas airplanes did, still do and undoubtedly will continue to do so for many years to come. Yet, Douglas has been in the red for a year and still is, a victim of the turbulent financial weather attendant on the change-over to the jet and the missile.

For example, not long ago, pay cuts ranging from five to 25 percent (at the very top level) were ordered for all Douglas salaried employees making more than $12,000 a year—the first widespread salary cut since the drastic post-war cutbacks in 1946, which affected the entire industry.

While the unions were charging that the pay cut was a move to undermine their position in contract negotiations, Donald Douglas, Sr., Board Chairman, and an elder statesman of the industry, commented simply that the action was necessary " to help place the company in a stronger competitive position at this crucial period."

This "crucial period" to those outside the industry was a period when Douglas jets were spanning oceans and continents, to the delight of air travellers and to the profit of airlines.

But this was the very problem. Boeing has it. And so does Lockheed and Convair. It is the new jet-liners.

In Douglas' case, it was the DC-8. Douglas has orders for some 155 of these fine aircraft, but development costs have been higher than expected, and it will take a little time before the company is breaking even. There were modifications, too, as there almost always are with a new aircraft. These contributed to the company's net loss of nearly $34 million at the end of their last fiscal year.

Basically, Douglas' problem is not different from others in this field. The phasing out of manned aircraft and the changes in missile techniques are leaving them without their bread-and-butter items. Douglas is cited because Douglas is a giant of the industry. Yet there are some indications that it will become a smaller company. It has written off most of the DC-8 costs at this point and is in a fairly good competitive position to profit on jet sales from now on. The company has plenty of cash, some $35 million, and working capital of around $154 million. In addition, the company recently tied in with France's Sud-Aviation to market the twin-jet *Caravelle*, a proven aircraft for short hauls.

The company, which has been reluctant to move into electronics, may be forced to use some of its cash to do just that in order to get in on some of the government contracts for research and development which are aiding some other airframe manufacturers. The company is talking about " additional cost-saving steps," of which one possibility is lay-offs which could further cut the 62,500 pay-roll—already down 7,000 from last year.

Meanwhile, what of the three which stand out? In contrast to Douglas' payroll reduction, increased volume of business at North American brought employment up to 64,220, compared with 53,820 at the end of the previous fiscal year.

North American reported that sales rose 16 percent and were the second highest in company history, exceeding one billion dollars for the second time in the past three years. Of interest in North American's report is that the six divisions "achieved significant gains in a variety of advanced technical and scientific fields, so that the company's capabilities continue to be broadened and strengthened to meet the challenge of the aero-space age.

" The resultant diversification may be measured by the growing proportion of the company's business in fields other than aircraft—missiles, electronics and electromechanical equipment, rocket engines, and atomics. During the past year they represented 43 percent of the total as against 20 percent of the company's sales when the separate divisions were established in 1955."

This diversification has placed the company in a better position to withstand sudden shifts in government programming. North American's sales last year were $1,045,000,000. The quarterly dividend was 50 cents a share, bringing it to $1 a share paid on the company's stock to April during the 1960 fiscal year. It was a good story that Chairman J. H. Kindelberger and President J. L. Atwood had to tell their shareholders. For the annual meeting there were outstanding 8,136,701 shares of capital stock held by 45,616 stockholders.

And what of The Martin Company? George M. Bunker, Chairman, and William B. Berger, President, were in the happy position of being able to tell their shareholders that " to the best of our knowledge, The Martin Company is engaged in the design, production of a greater number of military missiles than any other manufacturer in the United States, and in this area we are continuing to expand our activities."

Messrs. Bunker and Berger were also able to say that " the Company is also one of the few members of the slowly changing old-line aircraft manufacturing industry whose earnings increased in 1959." Martin sales last year were $532,707,022 compared with $483,643,681 the year before. This resulted in a net income per share of $4.34 as compared to the net income of $3.82 per share in 1958 after adjustment for the 5 percent stock dividend announced last December.

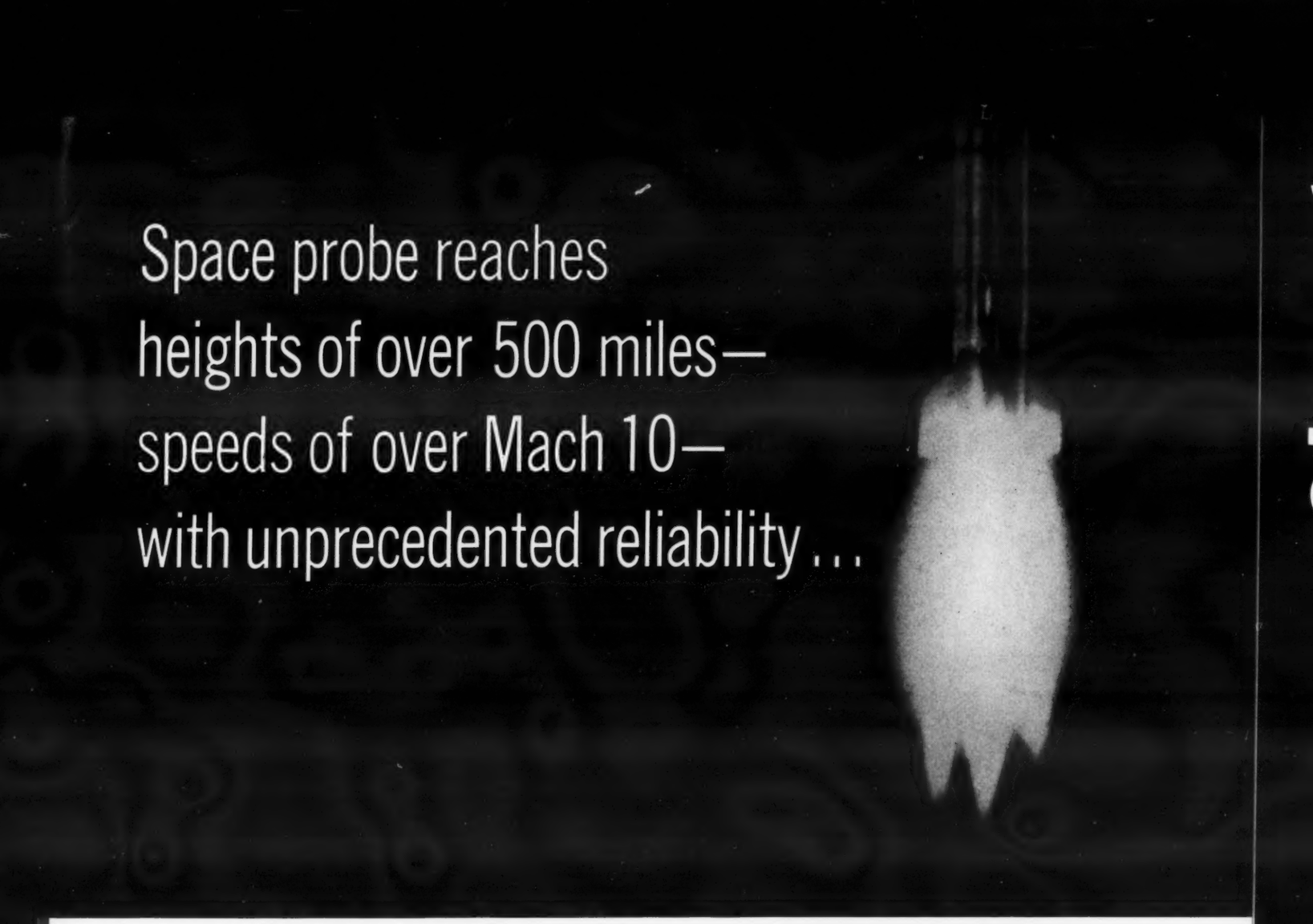
What is happening to the old-line aircraft industry is indicated by the fact that Martin, in reality, is no longer a member of the traditional old-line aircraft industry with which it used to be so firmly and properly identified. Instead, it has become a manufacturer of complex and diversified weapon systems, none of which includes a new aircraft design.

And what of Grumman? Widely diversified, the company is still in the aircraft business, particularly with its *Gulfstream* business aircraft, but fighter aircraft, a former mainstay of the output, are no longer in production. Grumman sales last year were $288,978,628, the largest annual volume of business the company has had since the war year of 1944 and representing an increase of approximately $64,000,000 over sales the year before. Grumman is one of the select group which have an unbroken record of dividend payments for a period of thirty years.

The Company points out that research, engineering and development work will continue in many fields of endeavor and that such work " reflects the guiding philosophy of Grumman."

Leroy R. Grumman, Chairman of the Board, and Leon A. Swirbul, President, both with thirty years' service with the company, report that " on the one hand we recognize that continued diversification and growth of the company is dependent upon further development of missiles, astro-vehicles and other advanced space age projects. On the other hand, we have a realization of the continued need for manned aircraft to fulfill the missions impossible to accomplish by other methods."

So, Grumman, Martin and North American, each in its own way, have been able to make the transition to a new aero-space age of manufacturing which every one in the industry knew was on the way, but which some were better prepared to meet than were others.



...AND BRISTOL SIDDELEY SUPPLY THE POWER

One of the largest manufacturers of motive power units in the world, Bristol Siddeley Engines Limited produce the Gamma. A liquid propellent rocket engine, the Gamma powers the Saunders-Roe Black Knight, Britain's highly successful space research vehicle. An extremely reliable powerplant, the Gamma produces a total sea-level thrust of 16,400 lb (7,438 kg) and nearly 19,000 lb (8,618 kg) outside the earth's atmosphere, for a total powerplant weight of only 700 lb.

At the Woomera rocket range in Australia, the Gamma has sent Black Knight over 500 miles into space at speeds in excess of Mach 10 with a reliability that is unprecedented.

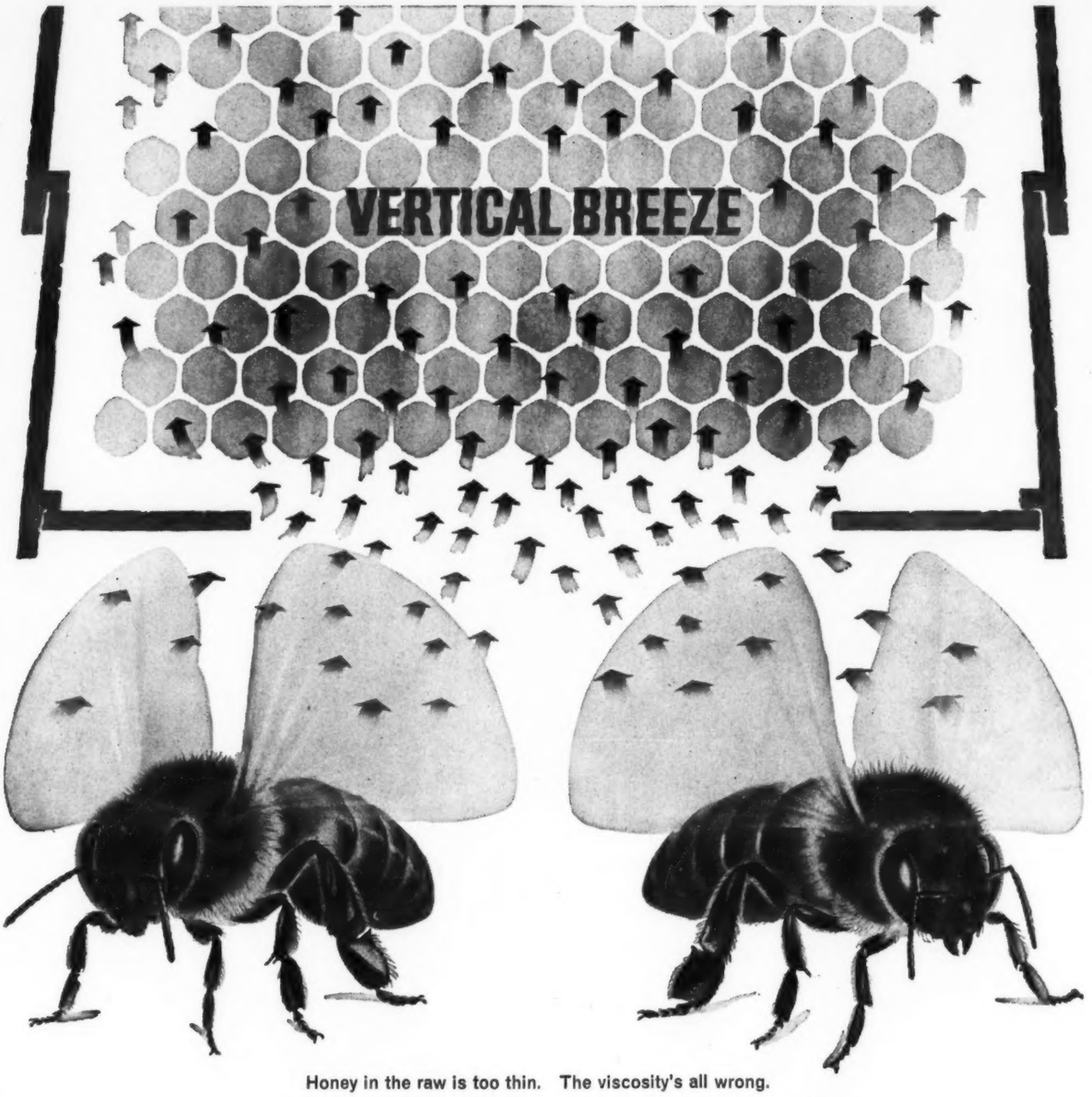
Since Bristol Siddeley's rocket division began work in 1946, it has developed a wide range of components. *By combining these components in single or multi-chamber layouts, thrust requirements from 500 lb up to 100,000 lb can be met.*

BRISTOL SIDDELEY ENGINES LIMITED

Bristol Siddeley Maybach diesel engines power Britain's fastest express train.

The Bristol Siddeley Orpheus powers the Fiat G 91 standard lightweight strike fighter.

The Bristol Siddeley Proteus powers the Britannia airliner.



Honey in the raw is too thin. The viscosity's all wrong.

The bees adjust matters by evaporation, fanning a forced draught up through the combs until in their judgment the product is right for its purpose. Hit-or-miss though the method seems, they achieve an extraordinary accuracy in meeting a self-imposed specification.

What's good enough for bees is one thing: meeting AIR BP specifications is another. A good many years of relentless research, development and performance testing under service conditions have been spent in proving to the hilt that the current range of BP aero lubricants and special products meets every relevant specification in every particular, and with a margin in hand. AIR BP supplies piston and turbine engine oils and a full range of special products to British and American standards as an essential part of a complete service to aviation.

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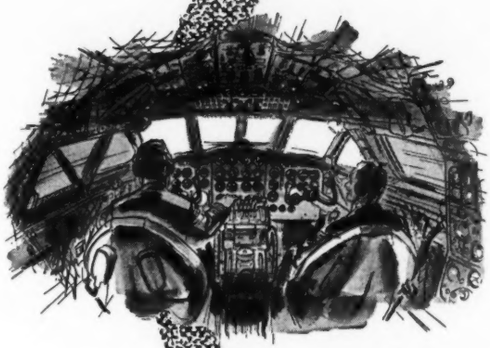


Preparing air traffic control for the Jet age:

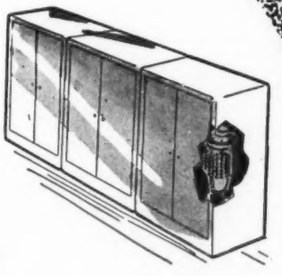
Automatic flight progress display

SATCO

Automatic Air Traffic Control System

SATCO comprises the ground equipment to predict, co-ordinate, check and display the movement of air traffic en-route and in terminal areas.
It provides an extremely rapid means for calculating flight paths, for detecting potential conflicts and for coordination of traffic control between controllers and between Area Control Centres. Special features are included for military/civil coordination and for controlling jet traffic.

The system has been ordered by the Netherlands' government and the first phase is now under operational test.

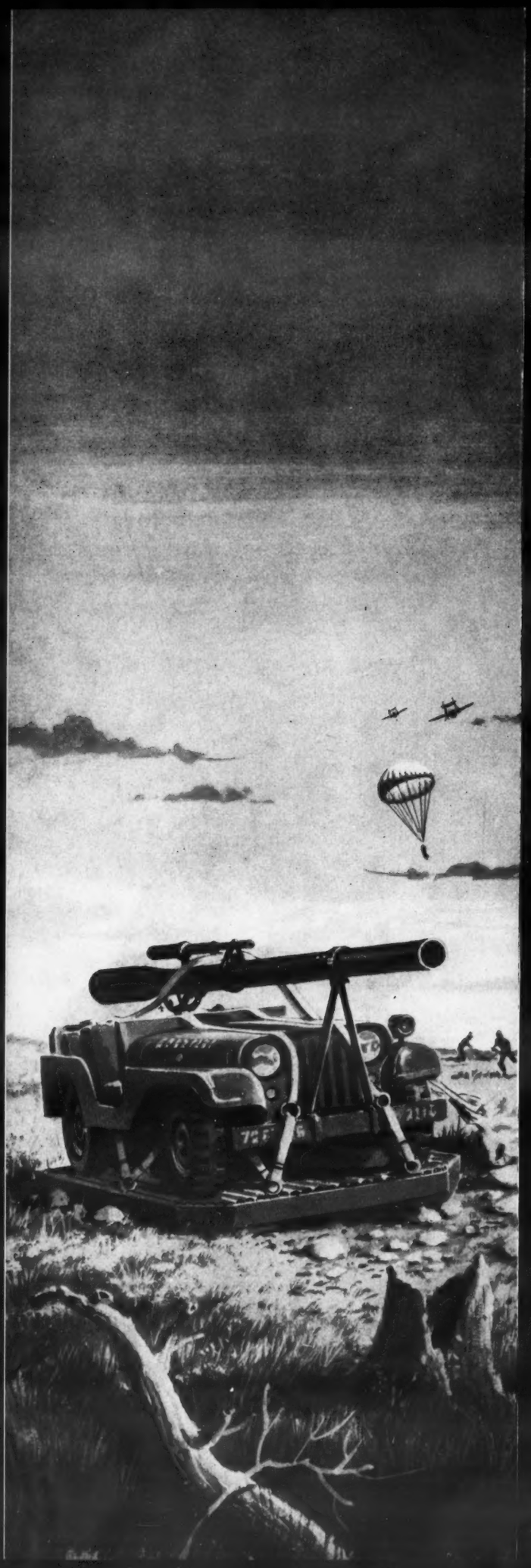


Computer and memory drum - calculations and conflict search

Flight planning

SIGNAAL

N.V. HOLLANDSE SIGNAALAPPARATEN HENGELO - NETHERLANDS



NEW BATTLEFIELD MOBILITY FOR CREW-SERVED WEAPONS

WITH THE VERTOL 107

The twin-turbine Vertol 107, prototype of the army YHC-1A light tactical helicopter, is giving new meaning to an old word — mobility.

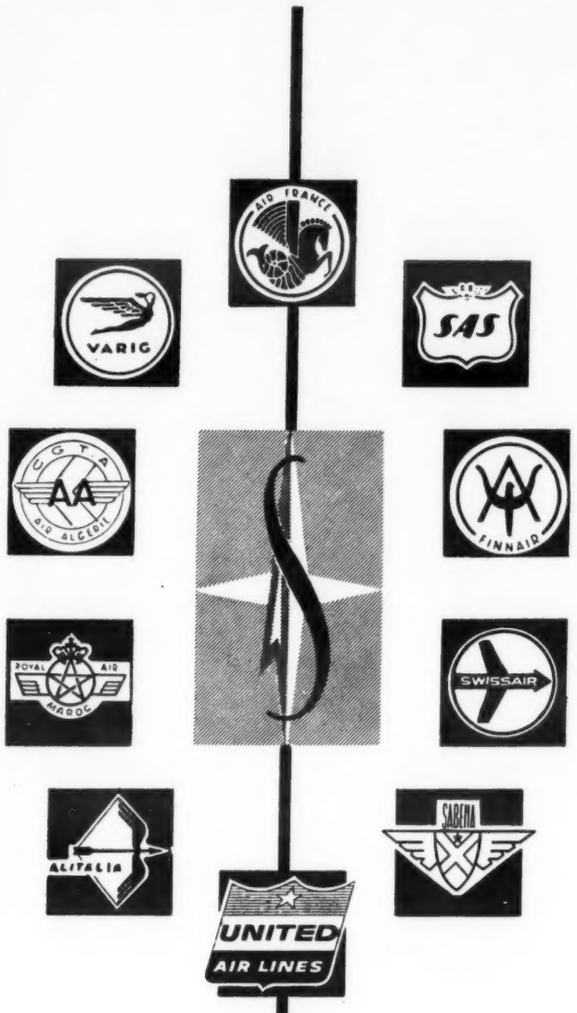
In "shoot and scoot" tactics for crew served weapons, the YHC-1A can swiftly transport three 106mm battalion anti-tank rifles each with 4-man crew and ammunition. Terrain is no obstacle. Each crew and weapon can be dropped off at pin-pointed firing positions to ambush advancing armor with convergent fire. Within minutes they can be scooped up and redeployed to engage another target miles away.

With its rear loading ramp and unobstructed payload compartment, this helicopter has the ability to airlift a complete Little John system and crew, laying fire on a target 60 miles away 35 minutes after receipt of orders.

Vertol's advanced YHC-1A and the forthcoming YHC-1B (Chinook), provide battlefield transportation which equals the advanced firepower of MoMAR — Mobile Modern Army.

VERTOL DIVISION BOEING

MORTON, PENNSYLVANIA



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For this reason, they have adopted the ideal aircraft for short and medium stages.

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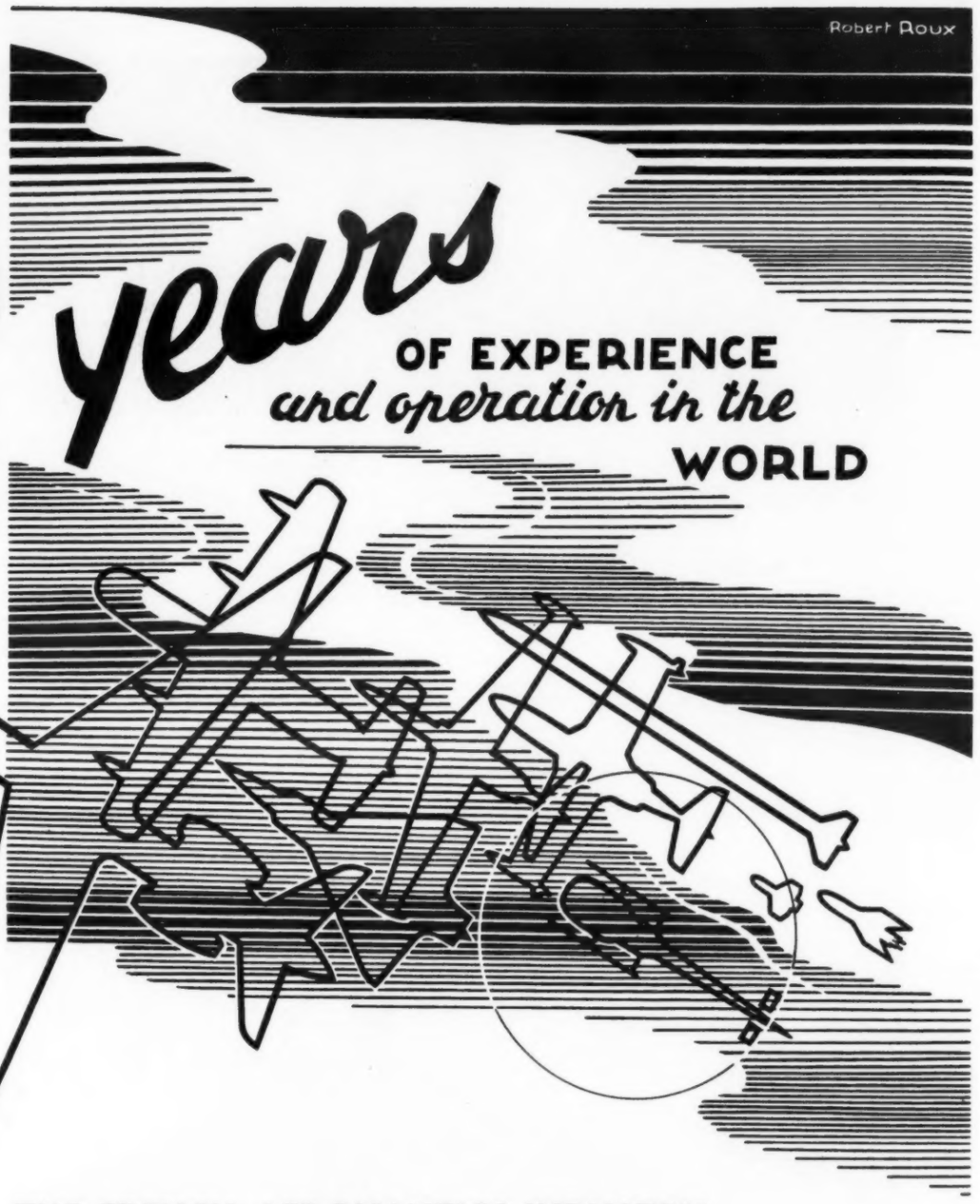

PROTOTYPES under study and construction

Breguet 941-942

Breguet 1150 Atlantic

Max Holste MH.260-262

Potez P. 840

Nord-Aviation C. 160 Transall

AIRCRAFT EXPORTED

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Nord-Aviation Noratlas and missiles

Sud-Aviation Caravelle, Djinn and Alouette

odel D 117, D 120, D 100 and D 140

Breguet 905 Fauvette sail-plane

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STC Precision Approach Radar *type SLA 3B2*

In addition, this equipment has been ordered for Whenuapai, Auckland, New Zealand, R.N.Z.A.F. Ohakea, New Zealand.
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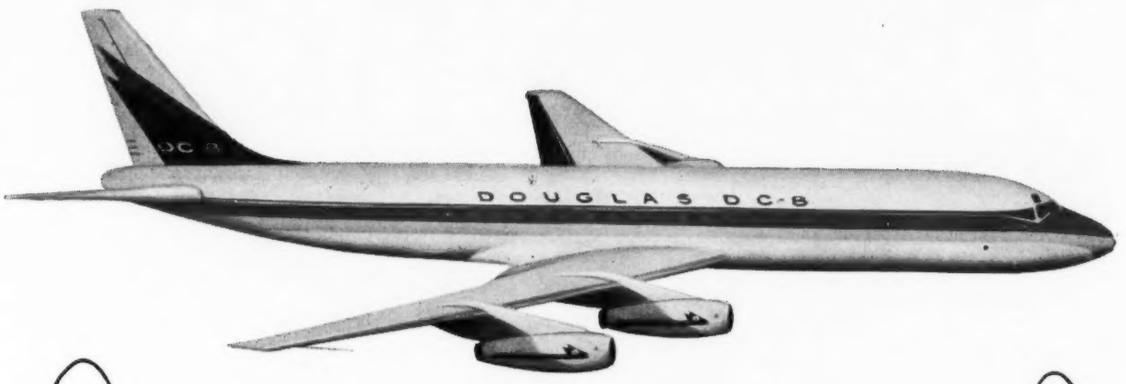
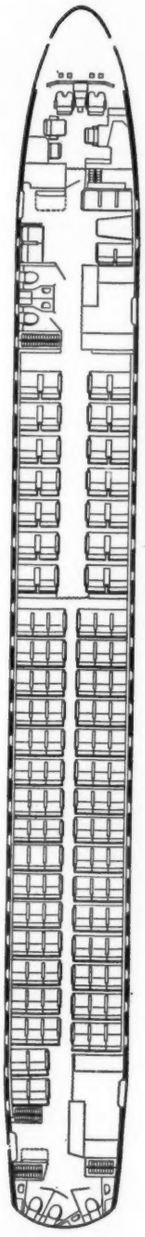


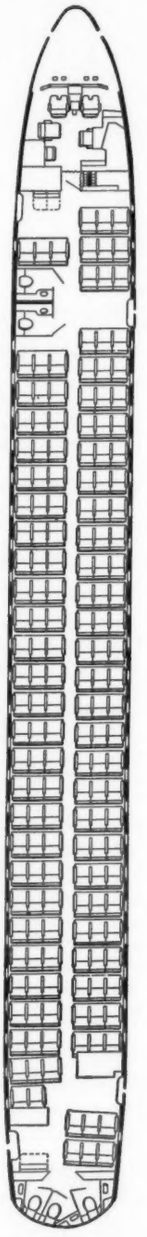


Flexible interior arrangements

...another excellence built into the DC-8

Because seating arrangements in the DC-8 are not dependent on fixed sidewall utilities, changes in interior configuration can be made in minutes.

Basically, only seating units and cabin partitions need to be moved. Since these attach to parallel tracks, they allow for an almost unlimited variety of arrangements. Superior flexibility allows the DC-8 to be adapted to changing airline needs with a minimum of ground time. It is a design feature developed from the unmatched experience of Douglas in building transports that meet the specific needs of airlines.



129 PASSENGERS

176 PASSENGERS

DOUGLAS DC-8

"THE AIRLINE PROFITMAKER"

LOW OPERATING COSTS • HIGH PRODUCTIVITY • DEPENDABILITY • DURABILITY

The trend is towards **AIR PARTNERSHIP**

More airlines (and airports) are adopting the Air Partner for Jet-liner starting

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SOUTH AFRICAN AIRWAYS
TRANS-CANADA AIRLINES . . .

These international airlines all use or have ordered the Atlas Copco Air Partner. Airports are also beginning to provide Air Partners as part of their ground service. Idlewild, Orly, Rome and Dusseldorf are among the first! A mobile starting unit which delivers *continuous power*, the Air Partner can be used on all jet and turbo-prop airliners with air turbine starters. A touch of the controls and it becomes an air-conditioning unit; fix a special mouthpiece to the air hose, and you have a de-icing machine. The Air Partner can be mounted on a trailer or any suitably-sized chassis—Ford, Volvo, Willys, etc.

MINIMUM MAINTENANCE

The Air Partner consists of an Atlas Copco TWIN-AIR rotary screw compressor—a design based on some ten years' testing and operating experience. Supplying a constant flow of warm, oil-free air—an essential condition for efficient starting—this compressor has few moving parts. Wear is thus practically eliminated and maintenance costs cut to a minimum—10,000 hours is the normal period between overhauls for screw compressors of this type. Maintenance on the Air Partner can be carried out by airline personnel anywhere in the world or through the Atlas Copco sales and service organisation established in ninety countries.

WRITE FOR THE BOOKLET

An Atlas Copco booklet giving full details of the Air Partner is readily available on request. Write for a copy to your local Atlas Copco company or agent or to the address below.

Atlas Copco

AIR PARTNER

a contribution to the jet age of air travel

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INTERAVIA AIR LETTER reports...*

The 13th IATA Annual Technical Conference, the largest of its kind ever held, closed in Lucerne on May 11th. In addition to three major committees working on doppler radar and presentation of flight information in the cockpit, air traffic control, and jet maintenance and engineering problems, the conference also discussed fuel specifications.

The committee which examined the use of doppler navigation systems concluded that doppler is giving accuracies of 1-1.5 per cent in operational use along track and 3.5-4 per cent across track. With more accurate sources of heading reference on board the aircraft, these figures could be substantially improved. The system offered considerable advantages in long-distance flying by reducing flight times, fuel consumption and fuel load carried. At a later stage it was seen as an aid in airway and terminal area flying, but air traffic control procedures would have to be developed to correlate the use of doppler with other aids.

The committee considering turbine-powered operations in relation to air traffic control emphasized the need for greater coordination between States (particularly in Europe) to avoid the discontinuity in ATC service resulting from national boundaries. The maintenance and engineering committee reported on problems encountered during the first year of jet operations. Discussions ranged from equipment and component design to the standardization of training and licensing of maintenance personnel to meet the spread of aircraft pooling agreements.

The committee on jet fuels discussed fuel cleanliness, filtration, standardized refuelling systems and fuel specifications. It was suggested that fuel should be delivered in terms of BTU content. The committee noted that present fuel costs account for about 15 per cent of an airline's operating and maintenance expenses; as more jets enter service, however, this may rise as high as 30 per cent.

The conference record will now be reviewed by the IATA Technical Committee.

●

A drastic reappraisal of both offence and defence in the USA and the U.K. has resulted from studies of the vulnerability of static weapons sites and ICBM and IRBM accuracy; the main emphasis is now centred on mobility and variety of delivery. While the big, immobile ballistic missiles will continue to be a main U.S. deterrent, complementary mobile systems in the shape of *Sky Bolt* and *Polaris* are being developed. The U.K., having assessed the enormous cost of trying to counter only a portion of the Soviet threat facing her, has abandoned *Blue Streak* and selected the Douglas *Sky Bolt*.

Sky Bolt (official designation WS-138A) is a two-stage rocket-powered strategic air-to-surface missile (ALBM = air-launched ballistic missile). It will have a range of 1,000 miles and an inertial guidance system by the Northrop Nortronics Division. Aerojet-General Corporation has been selected to develop the solid-propellant rocket engine. The main problem with *Sky Bolt* is to ensure accuracy of position fixing at the time of release from the bomber, and planning the maximum number of *Sky Bolt*-equipped aircraft either in the air or on ground alert when warning of attack is given. The USAF intends to get long-range ground-air position checking if possible, and BMEWS warning will later be supplemented by reconnaissance satellites.

After completion of an exhaustive analysis, Douglas was awarded a USAF research and development contract for the *Sky Bolt* ALBM in 1959. For fiscal 1960, allocations total $35 million, for fiscal 1961 $70 million. Pentagon experts estimate that the five-year research and development programme will cost about $1,000 million. The USAF plans to use *Sky Bolt* on B-52s and B-58s as a weapon for hitting both hard and soft missile sites and the enemy's defensive radar and anti-aircraft sites. In the U.K. the RAF would employ the weapon in a similar manner. *Sky Bolt* would be mounted in *Vulcan B.2* and *Victor B.2* long-range bombers, which already have the latest anti-radar and anti-missile countermeasures equipment. This would ensure a high degree of immunity for the deterrent for many years.

It is now highly unlikely that there will be any future requirement for a supersonic aircraft to carry *Sky Bolt*, and emphasis will be on endurance and not speed. While the USAF is studying a subsonic atomic aircraft for *Sky Bolt*, the RAF may well supplement V-bombers with a military version of the *Super VC. 10* and, like the *Vulcan*, capable of carrying four of the missiles.

The British Air Ministry is now conducting an intensive study of the modifications required for the *Victor* and *Vulcan* to allow them to operate *Sky Bolt*. A great deal of new electronic equipment is called for, and careful programming will be required to ensure that the V-bombers in service and building can be fully converted by 1965. Teams from both A. V. Roe Weapons Division and Handley Page have already held discussions with Douglas.

●

Aviones Lockheed-Kaiser Argentina is the name of a new joint company founded by Lockheed Aircraft International and Industrias Kaiser Argentina to handle production of at least 500 LASA-60 single-engine light utility transports. The LASA-60 will also be manufactured in Mexico by Lockheed-Azcarate and in Italy by Aeronautica Macchi.

Aviones Lockheed-Kaiser will start with a working capital of 160 million pesos (approximately $2 million) contributed equally by both partners in cash, equipment and facilities. Production of the LASA-60 is scheduled to start this year at a new plant to be constructed immediately at Córdoba, adjacent to the Industrias Kaiser Argentina automobile plant, some 400 miles northwest of Buenos Aires.

The LASA-60 is a strut-braced monoplane of all-metal construction, and its design has been planned to meet requirements for an aircraft capable of operating from short, rough landing strips. The production version will be powered by a 260 h.p. Continental IO-470-C supercharged fuel injection engine. This powerplant, in conjunction with the high-lift wing and Fowler flaps, permits the aircraft to operate from high altitude airfields in high ambient temperatures with little or no load restrictions. The LASA-60 can carry up to 1,590 lb of useful load and can be employed as cargo carrier, aerial ambulance or agricultural sprayer. The aircraft is readily convertible from one configuration to another. To extend the field of operations the undercarriage can be equipped with floats or skis.

●

Magirus-Deutz Orion 70 and Orion 250 aircraft towing vehicles: In No. 4/1960, page 487, pictures were published of the *Orion 70* and *Orion 250* aircraft towing vehicles built by Klöckner-Humboldt-Deutz. The picture captions describing the two vehicles were, however, reversed in error. The vehicle on the left is the *Orion 70*, that on the right the *Orion 250*.

●

Convair Division of General Dynamics Corporation has received an Air Materiel Command Ballistic Missiles Center $118 million contract for continued production of the *Atlas* ICBM, both as a weapons system and for space booster uses.

●

The A.C. Spark Plug Division of General Motors Corporation has received an Air Materiel Command Ballistic Missiles Center contract valued at $84 million for research and development of inertial guidance systems, including ground operating equipment, for the USAF's *Titan* ICBM. The contract confirms a previous letter authorizing A.C. Spark Plug to begin work on the project. The inertial guidance system was developed jointly by the company and the Instrumentation Laboratory of Massachusetts Institute of Technology.

●

Ford Motor Company's Aeronutronic Division has handed down a subcontract to Telecomputing Corporation, of Los Angeles, for design and development of a two-axis free gyro for use in the U.S. Army's *Shillelagh* combat zone surface-to-surface missile. Aeronutronic is developing the *Shillelagh* under a $28.3 million programme, for which the initial development contract was awarded in early 1959. Other subcontractors are the Raytheon Company (fire control subsystem) and Genisco Inc. (accelerometer). Technical control of the programme is in the hands of the Army Rocket and Guided Missile Agency, Redstone Arsenal, Alabama.

●

Saab Aircraft Co. recently handed over the last production *Lansen*, a J 32B night and all-weather interceptor, to the Swedish Air Force. The *Lansen* went into production in 1953, and the Swedish Air Force now has some 20 squadrons of the aircraft in service. Produced in three different versions, the A 32A all-weather attack, the J 32B night fighter and the S 32C reconnaissance aircraft, the *Lansen* series is the second largest ever produced by Saab, only the J 29 *Flying Barrel* having been manufactured in larger numbers.

* Interavia Air Letter is a daily international news digest published in English, French ("Courrier Aérien") and German ("Luft-Post"). All rights reserved.

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INTERNATIONAL MEETINGS AND CONFERENCES

June 15th-29th: Seventh International Congress on Electronics and Nucleonics. Rome.

June 19th-22nd: American Institute of Chemical Engineers Meeting. Mexico City.

June 20th-21st: Air Force Missile Development Center and University of New Mexico, series of seminars. Cloudcroft, N. Mex.

June 20th-23rd: AGARD Avionics Panel, 5th Ionospheric Research Committee Meeting, on Radio Wave Absorption. Athens.

June 22nd-24th: Standards and Electronic Measurements Conference. Boulder, Colorado.

June 23rd-25th: Sixteenth Annual Meeting of the Institute of Navigation. Colorado Springs.

June 25th-July 5th: AACC, ISA, ASME, IRE, AICHE, 1st International Congress for Automatic Control. Moscow.

June 27th-28th: Fourth National Convention on Military Electronics. Washington, D.C.

June 27th-30th: Institute of Aeronautical Sciences Summer Meeting. Los Angeles, Calif.

July 1st-4th: Twelfth Round-Sicily Air Race, organized by Palermo Aero Club. Palermo, Sicily.

July 8th-9th: British Lockheed Trophy. Baginton, Coventry.

July 8th-10th: Aero Club of Italy Rally.

July 24th-Aug. 1st: British Gliding Association, 2nd National Gliding Week. Sutton Bank, Yorkshire; Dunstable, Bedfordshire; Camphill, Derby.

July 31st-Aug. 7th: World Parachuting Championships, organized by the Aero Club of the People's Republic of Bulgaria. Musatchevo, Sofia.

Aug. 11th: Aircraft Nuclear Propulsion and Small Reactors Information Meetings. Oak Ridge, Tenn.

Aug. 15th-20th: International Astronautical Federation, 11th Congress. Stockholm.

Aug. 28th-Sept. 4th: FAI World Aerobatics Championships, organized by the Czechoslovak Aero Club.

Aug. 31st-Sept. 7th: Tenth International Congress of Applied Mechanics. Stresa, Italy.

Sept. 5th-11th: SBAC Air Show. Farnborough.

Sept. 5th-17th: Ninth International Congress of Photogrammetry. London.

Sept. 6th-24th: ICAO Legal Committee, 13th Session. Montreal.

Sept. 8th: IATA Executive Committee, 48th Meeting. Stockholm.

Sept. 12th-16th: IATA 16th Annual General Meeting. Copenhagen.

Sept. 12th-17th: Second Congress of the International Council of the Aeronautical Sciences. Zurich.

Sept. 15th-16th: National Association of State Aviation Officials, Annual Meeting. Jackson, Wyoming.

Sept. 16th: IATA Executive Committee, 49th Meeting. Copenhagen.

Sept. 20th: IATA Composite and Joint Meeting of Traffic Conferences. Cannes.

Sept. 20th-22nd: National Business Aircraft Association, Annual Meeting and Forum. Los Angeles.

Sept. 22nd-Oct. 2nd: Tenth International Engineering Show. Turin.

Oct. 3rd-5th: IAS Midwestern Meeting on Air Logistics. Tulsa, Okla.

Oct. 3rd-7th: Air Traffic Control Association meeting. San Francisco, Calif.

Oct. 4th-12th: Second Electronic Computer Exhibition. London.

Oct. 8th-9th: Genoa Air Rally.

Oct. 10th-14th: SAE National Aeronautic Meeting. Los Angeles.

The European F-104 Programme

Following a report in the April issue of *Interavia* Review on the military and industrial background of the F-104 production in Europe, some details of the practical preparations for putting the Lockheed F-104G *Super Starfighter* into operation are given on this page.

An F-104A *Starfighter* from the USAF units stationed in Spain recently made its *début* before the German public at Hanover-Langenhagen Airport, and the German Air Force took the opportunity to put spectators in the picture regarding its plans for training F-104 pilots and forming units.

Lieutenant-Colonel G. Rall, head of the Air Force department responsible for the preparatory work on the F-104, gave a report on the training of the first six German flight instructors in the USA. During a course at Randolph Air Force Base, Texas, Headquarters of the USAF Air Training Command, the flight instructors each spent an average 32 hours at the controls of the supersonic fighter and had ample opportunity to familiarize themselves with it in all flight conditions at speeds of up to Mach 2.2, and get to know all the variants of its equipment. These pilots are now taking over the training of further instructors in West Germany, to enable a first F-104 training squadron to be formed at Nörvenich military airfield, near Cologne, in summer this year.

Next, General J. Kammhuber, Inspector of the Air Force, gave an outline of the F-104 training programme. After 330 hours' basic training and the necessary instruction in the use of weapons, trainees must spend 330 hours on Republic F-84 and North American F-86 operational aircraft. Training on F-104Fs begins only after this 660-hour preparation. Simultaneously with the pilots, mechanics are being trained at Kaufbeuren, Bavaria, and the rest of the ground crews at Fassberg, on the Lüneburg Heath.

Four of the 30 F-104F trainers ordered in the USA arrived at Bremerhaven by sea at the beginning of May, and Lockheed is to deliver the remaining 26 by October.

As for the operational units, it is planned to convert the 31st Fighter-Bomber Wing, the oldest unit of the German Air Force, to F-104G *Super Starfighters* by the end of 1961. General Kammhuber expects the first deliveries from " Arge 104 Süd " (the southern group of manufacturers) by October, 1961 and hopes that conversion of all Air Force fighter units to F-104s will be completed by 1965.

The third speaker, Dr. Th. Benecke, Head of the Air Force Section of the Technical Department of the Federal Ministry of Defence, dealt with a few points in the technical programme for the F-104G, mentioning in passing that this version would, with very slight alterations, also be placed in service with the Netherlands, Belgian and Italian Air Forces, and with Canadian Air Force units in Germany.

* * *

As regards the common production of the F-104G, the coordination office for European licence production at Koblenz is preparing a programme covering the construction of 799 of the aircraft and running until the end of 1965. Planning is in the hands of various working committees: 1. airframe; 2. engine; 3. equipment, subdivided into: *a)* hydraulic, pressurization and refuelling systems; *b)* instruments; *c)* low-power electrical systems; *d)* ground equipment; *e)* electronic equipment; *f)* special equipment (armament).

The following firms are engaged in production:

Airframes : The northern group, comprising the Netherlands firms of Fokker and Aviolanda and the West German manufacturers Hamburger Flugzeugbau, Weser Flugzeugbau, Focke-Wulf (a total of 400 airframes, with Fokker responsible for final assembly and flight testing). *The western group*, comprising the Belgian companies SABCA and Avions Fairey (189 airframes; final assembly and flight testing by SABCA). *The southern group*, consisting of the German firms Messerschmitt, Heinkel, Dornier and Siebel (210 airframes; final assembly and flight testing by Messerschmitt).

Engines : The production of about 2,000 engines has been shared out among American and European firms, with a substantial proportion of the funds allocated going to the USA for supplies, royalties, etc. In Europe the Belgian company FN, Fabrique Nationale d'Armes de Guerre, and the West German BMW-Triebwerkbau GmbH will manufacture the engines, probably on a 60-40 percent basis. Many other firms will, of course, receive subcontracts.

Participation of other firms : According to a report from *Interavia's* Rome correspondent, it is likely that the Italian firms of Fiat, Industrie Meccaniche Aeronautiche Aerfer and Siai Marchetti will also be involved in the European production programme, as soon as certain preliminary details of a financial nature have been settled with the Italian authorities.

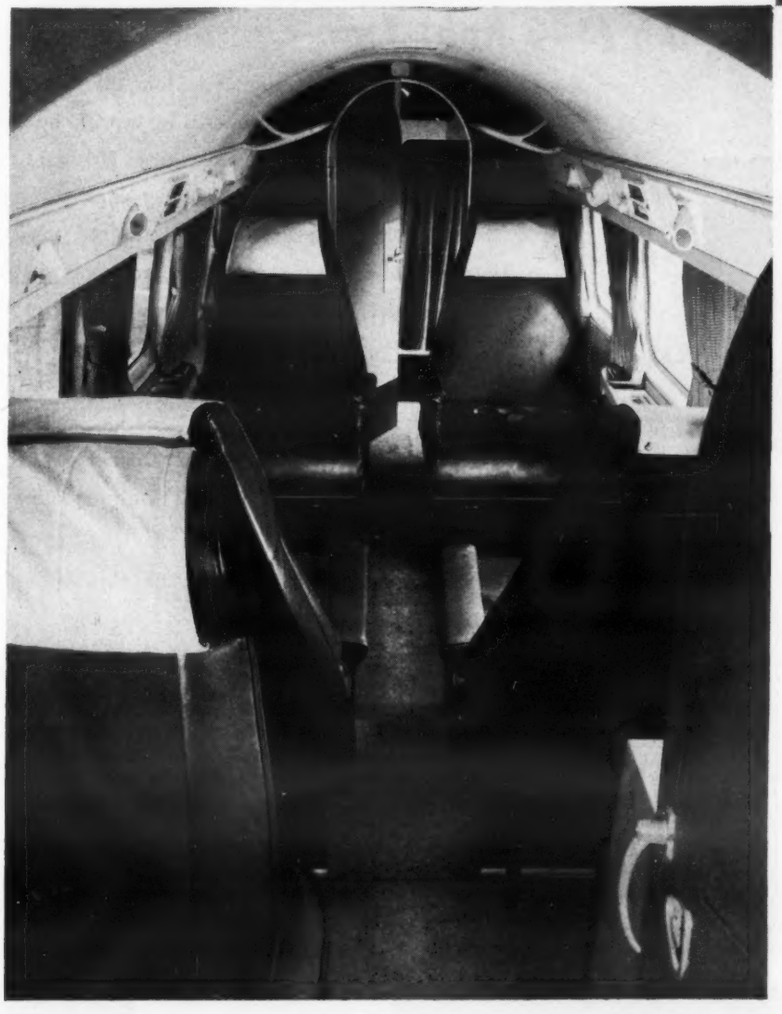
Bruno Gumpert

Bruno Gumpert is no longer with us. The internationally famous Austrian gliding pioneer, sailplane designer, aerobatic expert, jet pilot and Major in the Austrian Air Force, died on Monday, April 25th, 1960 after a long stomach illness. He was planning to fly the very day before he died, intending, as usual, to give a low-level aerobatic display at a sports flying meeting...

Born in Vienna on November 17th, 1907, Bruno Gumpert took up gliding in 1927. A Hauptingenieur in the Luftwaffe during the last war, he played an important part in developing and testing the fuel metering control for the Jumo 004 jet engine. After the war he spent some years developing gas turbines for Turboméca in southern France; in 1954 he founded the Versuchsanstalt für Luftfahrt (Aeronautical Test Establishment) in Vienna, and in 1957 he re-entered the Austrian Air Force, which was at that time in process of re-formation. He was on the Committee of the Austrian Aero Club and represented his country in OSTIV.

The *Dove*

for personal and business travel



Elegant

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AIRCRAFT · ENGINES · PROPELLERS

PIPER AZTEC

New 215 mph (346 kph) Twin-Engine Transport

FAST... Aztec's jet-type "flying tail" adds speed, stability.

ROOMY... Five ride in roomy luxury, with ample allowance for baggage.

The Piper Aztec, newest, largest, fastest aircraft to join the Piper fleet, is an over-200-mph (320-kph) twin powered by two 250 hp Lycoming engines. The Aztec carries a useful load of *over one ton* (over 900 kgs) ... takes off in less space, lands in less space and has a higher single-engine ceiling than any other twin-engine airplane in its class carrying a similar payload. With full 144-gallon (544-litre) standard fuel, five 170-pound (77-kg.) passengers, full radio and instrumentation for instrument flight, the Aztec cruises 205 mph (330 kph) at 7,000 feet (2,100 metres) (75% power) and has range of over five hours. Piper production efficiency permits the Aztec, fully equipped, to be priced well below any other twin in its class.

EFFICIENT... Piper Aztec has highest single-engine ceiling of any plane in its class carrying similar payload.

AZTEC SPECIFICATIONS

Engines (2)	Lycoming O-540	
Horsepower and RPM	250 at 2575	
Gross Weight	(lbs) 4800	(kgs) 2177
Empty Weight	(lbs) 2775	(kgs) 1259
Useful Load	(lbs) 2025	(kgs) 918
Top Speed	(mph) 215	(kph) 346
Cruising Speed	(at 7000 ft)-205 mph	(at 2134 met)-330 kph
Stalling Speed	(mph) 62	(kph) 100
Rate of Climb	(fpm) 1650	(mpm) 503
Service Ceiling (ft)	22,500	(met) 6,858
Absolute Ceiling (ft)	23,750	(met) 7,239
Fuel Consumption	(gph) 28	(lph) 106
Max. Range with Standard Fuel	(miles) 1,400	(km) 2,253

PIPER

AIRCRAFT CORPORATION
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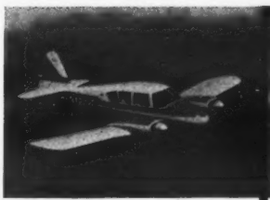
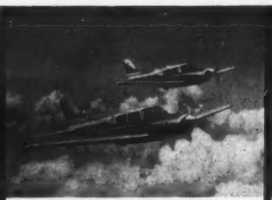
A PIPER PLANE FOR EVERY PURPOSE



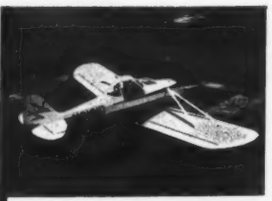
APACHE. Four or five passenger twin, cruises 171 mph (275 kph). Most economical to buy and fly.



COMANCHE. Record-holder for efficiency and reliability. With 180 or 250 horsepower.

TRI-PACER. CARIB-BEAN lowest cost, easiest-to-fly, four-place aircraft.

SUPER CUB. World-famous utility plane, with short, rough field, high altitude capability.



PAWNEE. New agricultural plane for efficient dispersal of dust or spray.

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of the French aircraft industry to foreign customers

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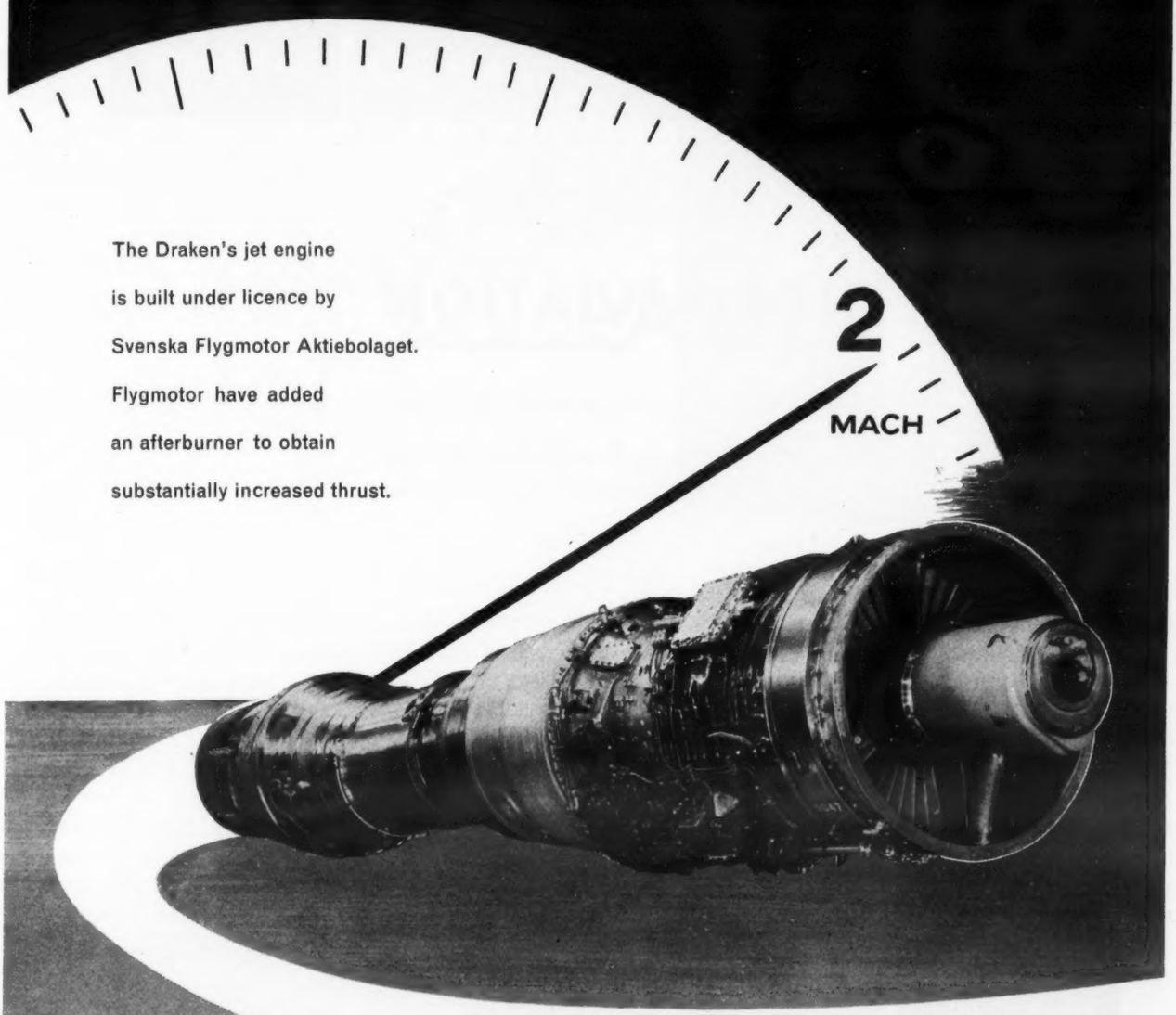
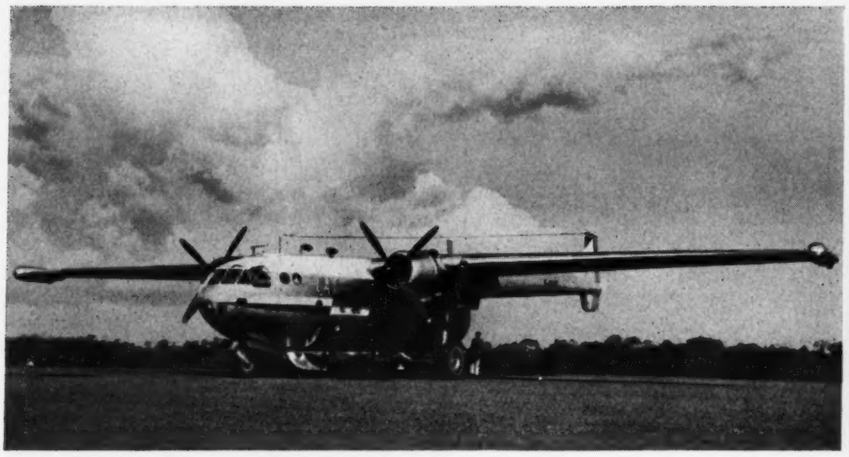
BOEING 720

TWICE
the speed of sound

The Draken's jet engine
is built under licence by
Svenska Flygmotor Aktiebolaget.
Flygmotor have added
an afterburner to obtain
substantially increased thrust.



SVENSKA FLYGMOTOR AKTIEBOLAGET
TROLLHÄTTAN — SWEDEN



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Manufacturers of SS.10 & SS.11 anti-tank missiles

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the latest observation aircraft

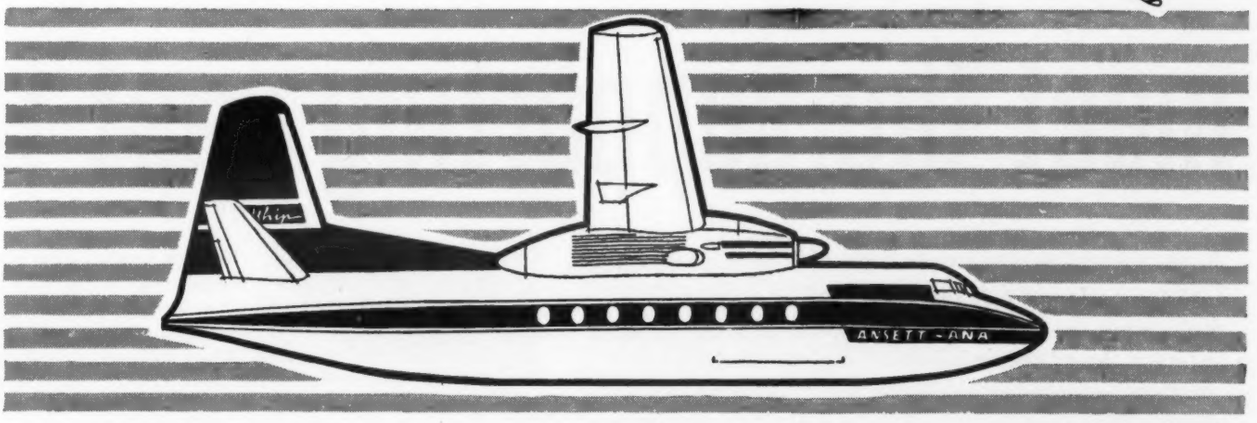
what mr. R. M. Ansett says:

„The first of our fleet of six F. 27 Friendships has already demonstrated its popularity and the most favourable passenger reaction has been accorded to the cabin appointments and the excellent visibility afforded by the high-wing construction. The Friendship's ability to operate from small airfields makes it particularly suitable for our extensive short-haul „feeder" routes whilst its operating economics to date indicate that it will prove a most profitable investment for the airline."

Mr. R. M. Ansett
Chairman and Managing Director
Ansett Transport Industries Ltd., Australia

what we add:

In 180,000 hours of smooth flying the Friendship has proved its excellent profit-earning capacity and operational reliability in regular airline service in four continents.



Fokker

The Fokker F. 27 is built under licence by Fairchild Engine and Airplane Corporation U.S.A.

you can build business on Friendship

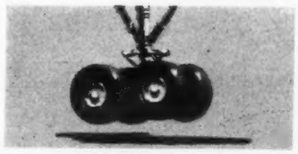
meet the supporting cast for

Across world skies these days the new jet-powered airliners are writing a proud chapter in aviation history.

Supporting the magnificent performance, comfort and safety of these "heavenly bodies" is a group of Goodyear products developed especially for their advanced requirements. They include tires able to withstand scorching high-speed take-offs and landings, powerful new brakes, and reliable skid-control devices.

While this Goodyear "supporting cast" may draw cheers from few but professional airmen, it shares credit for the matchless reliability which makes the world look up to these new jets.

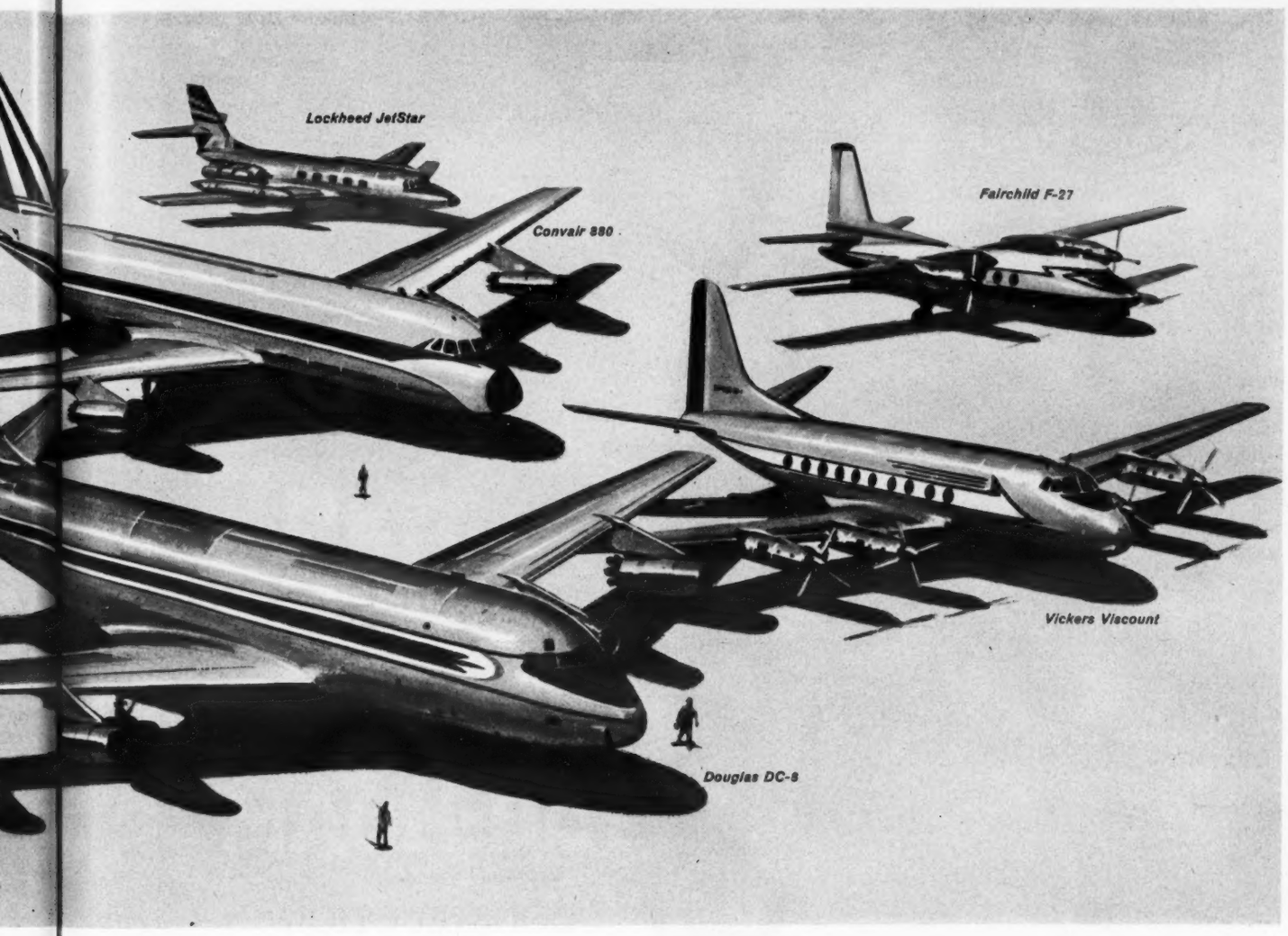
If you'd like more information on these Goodyear contributions to the Jet Age, write to Goodyear International Corporation, Aviation Products Division, Akron 16, Ohio, U.S.A.



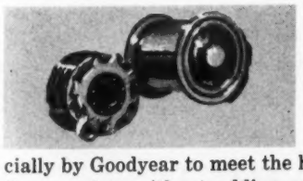
Take-off speeds between 248-320 kph with up to 136,080 kilos of jetliner are daily routine for new Goodyear fabric-reinforced tire. Noted for longer initial wear and longer retread wear, this rugged tire was first developed by Goodyear for U.S. Air Force jet fighters. Fabric reinforcement in tread reduces excessive wear caused by high-speed take-offs and landings. Airlines around the world find that this Goodyear tire delivers the extra margin of safety and dependability required by jetliners.

AVIATION PRODUCTS BY

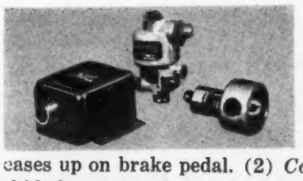
GOOD



the sky's newest stars!



Helping carry the load of many jet-powered airliners in ground operations are Goodyear wheels and brakes. Ready for the job were the Tri-Metallic Brake and Forged Aluminum Wheel—developed especially by Goodyear to meet the high load-carrying requirements of the new jets without adding extra weight. Again in 1960, as in each of the past 20 years, more commercial airliners are equipped with Goodyear Wheels and Brakes than all other makes combined.



Avoiding a skid is essential for a giant jet landing at over 160 kph. Goodyear's Anti-Skid System helps two ways: (1) *Foot thumper system* taps pilot's shoes when any wheel is about to skid. Pilot then eases up on brake pedal. (2) *Completely automatic system* senses skid danger – releases brake pressure on about-to-skid wheel – applies pressure when danger has passed. Small and lightweight, systems can be combined as pilot-modulated system.

YEAR

More airmen land on
Goodyear tires, wheels and brakes
than on any other make

AIRCRAFT
CONSTRUCTION

INDUSTRIE
MECCANICHE AERONAUTICHE MERIDIONALI

AERFER

Perfect vision is practically total blindness compared to NASARR . . . the lightweight, compact, all-weather radar system designed by Autonetics, a Division of North American Aviation, Inc. NASARR, the only multi-purpose radar system in production in the free world, has been selected to extend the capabilities of Germany's combat version of the Lockheed F-104G, being built for the German Air Force. NASARR has already been proved in service with the United States Air Force.

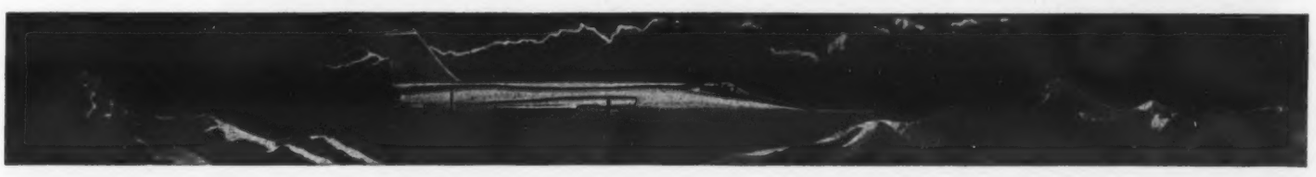
Autonetics is one of the world's leading producers of electronic devices for military and industrial use—with more than 14 years' successful experience in armament controls, inertial navigation, and data processing. Its products range from the inertial autonavigation system that guided the *USS Nautilus* under the polar ice to an advanced low-cost general-purpose digital computer for industrial and scientific use.

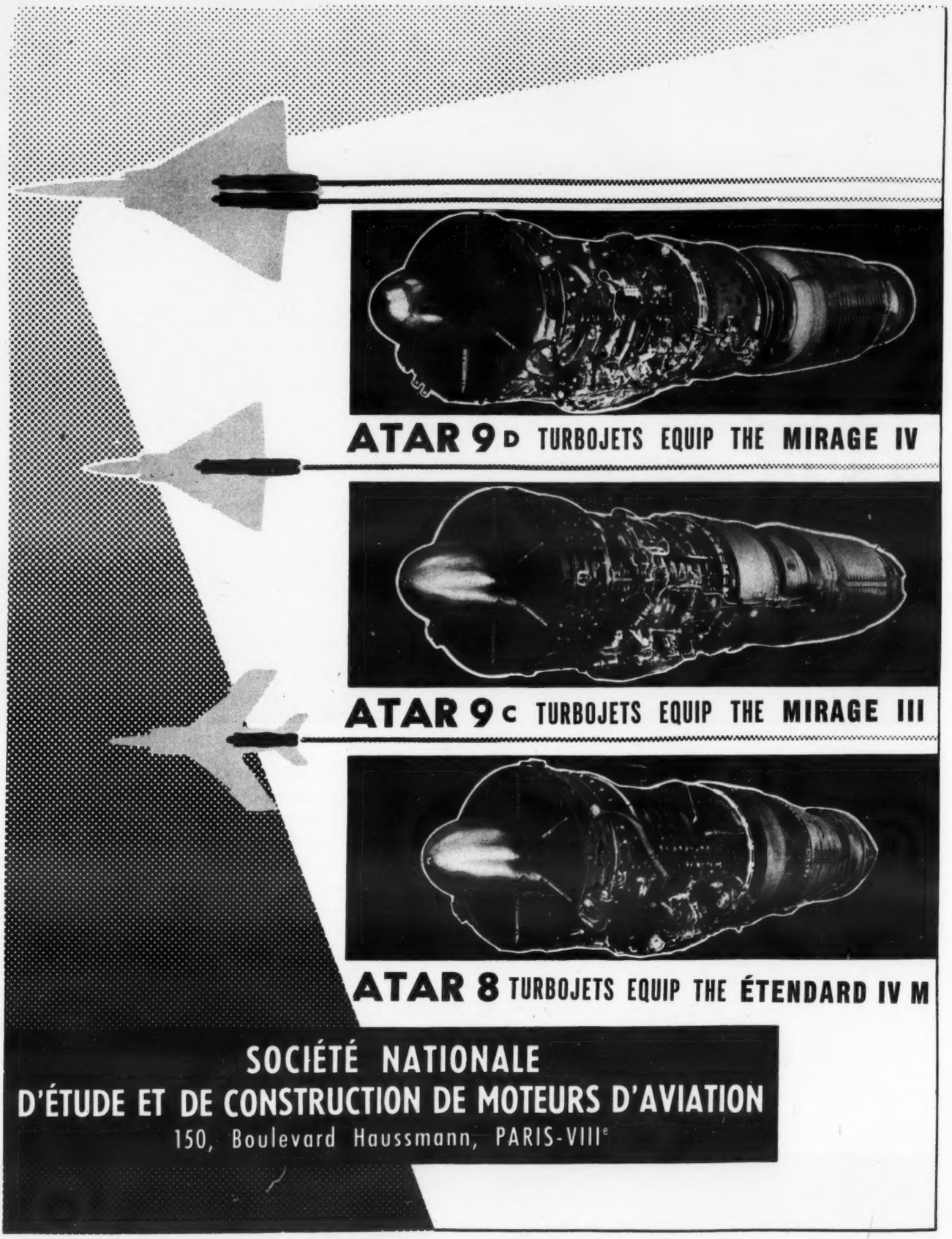
Autonetics now has a fully staffed branch office in Geneva, Switzerland, to serve continental Europe and the United Kingdom.

Autonetics
A DIVISION OF NORTH AMERICAN AVIATION, INC.

Downey, California, U.S.A.
EUROPEAN OFFICE: 29 Rue de la Coulouvrenière, Geneva, Switzerland

INERTIAL NAVIGATION / ARMAMENT AND FLIGHT CONTROL / COMPUTERS AND DATA SYSTEMS

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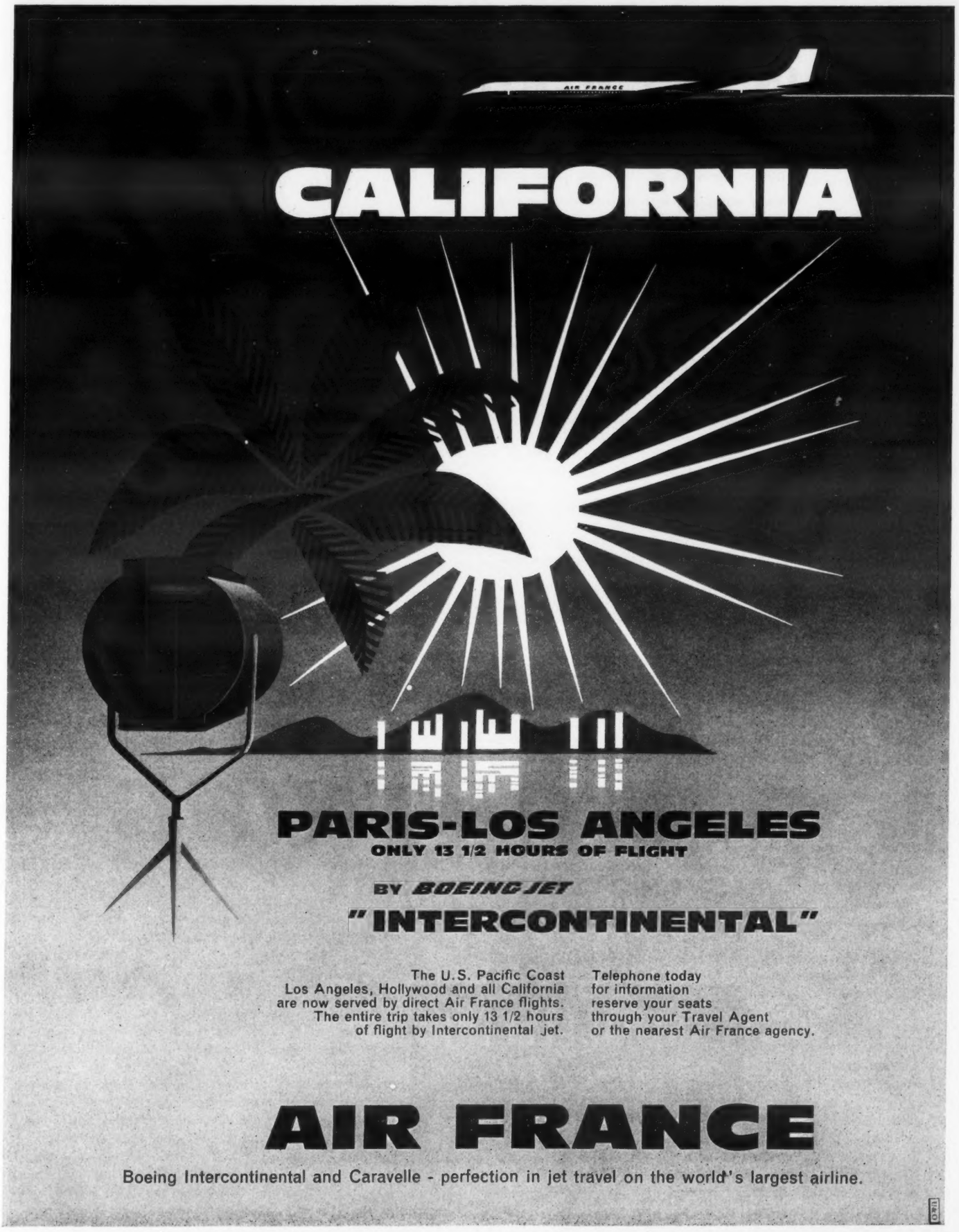
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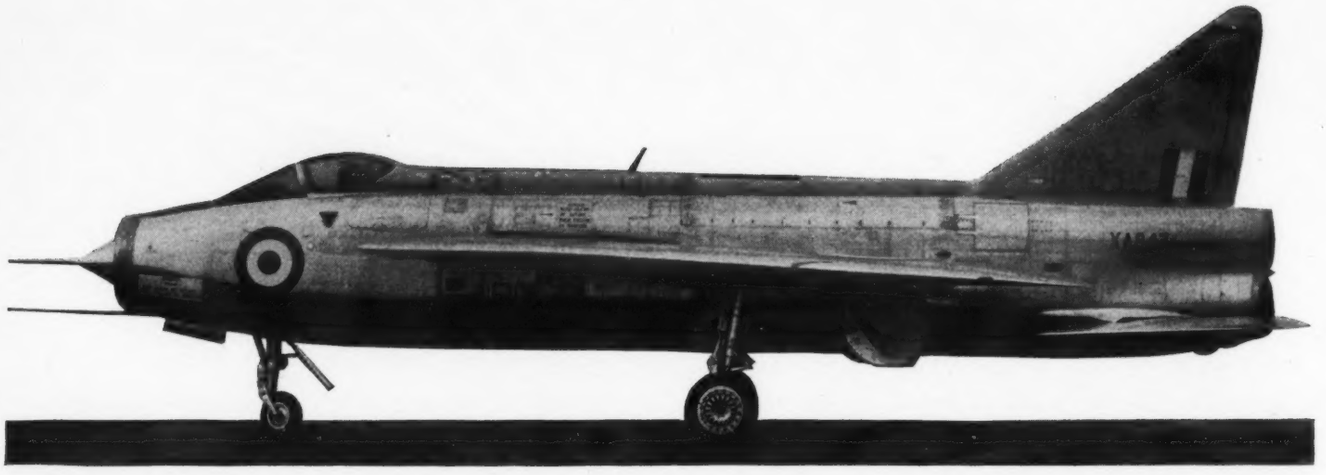

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Wanted: A New Strategic Concept and Orders for Industry

Aircraft in the service of the air surveyor and cartographer, aircraft as aids in agriculture and forestry, in short, "aircraft in blue dungarees"; the opening of the newest jet airport, Rome-Fiumicino; and last, but by no means least, a stroll through the German Air Show at Hanover-Langenhagen: these are the predominantly peaceful themes of the June issue of *Interavia*.

In view of the significant military and political events in recent weeks it might, perhaps, have been more appropriate to give the present issue a somewhat less civilian slant. We should not, however, overlook the fact that a number of events which at first glance would seem to be primarily of military importance have, in fact, aspects of civil interest, and that there is always a close relationship between a nation's military planning, its industrial needs and its financial resources. This applies to the East no less than the West.

*

At the beginning of May Prime Minister Khrushchev opened the joint session of the two Chambers of the Supreme Soviet with a flourish of trumpets. In connection with the shooting down of an American "high altitude research aircraft" over Soviet territory, he stressed in no uncertain terms that the USSR would not hesitate to use any means she thought fit to retaliate against acts of aggression from the West. Russia had, he added, not aircraft, but rockets on a "round-the-clock alert." And these rockets were "more accurate and technically more perfect than any of your bombers."

Fundamentally, all the Soviet Prime Minister was doing was emphasizing once again that Russia recognizes and appreciates the advantages of a deterrent strategy based on rockets and hydrogen warheads. A policy which, from the economic point of view, absorbs less resources than keeping mobilized the vast human potential necessary to maintain a conventional fighting force.

It is, however, significant that Khrushchev's other statements dealt less with strategic matters than with raising the standard of living, the prospects of equalling and surpassing American production, and increasing real wages.

*

In mid-April there was news from England of a right-about turn in British strategy: the abandonment of the almost complete de Havilland *Blue Streak* rocket, the cancellation of the Avro *Blue Steel Mk. 2* stand-off bomb, and the replacement of both weapons by American types.

For a better understanding of this courageous decision, which can certainly not have been an easy one for Defence Minister Harold Watkinson and Aviation Minister Duncan Sandys, it should be recalled how much energy Europe as a whole has expended during past years in developing weapons to enable her to free herself of dependence on America and stand on her own feet.

When Britain began work on the *Blue Streak*, this static deterrent was in line with current technology. It relied for its survival on the inaccuracy of the enemy's missiles, whose probable error was estimated at about 0.4 to 0.5 percent of their range. When, however, rockets became more accurate with the emergence of the radio inertial guidance system, the time for taking chances was over. Attacks on static missile bases once again became a paying proposition, and not even installation at hardened underground sites could fully guarantee the safety of the *Blue Streak*.

For this reason British defence planners appear to have modified their concept: underground launching sites were abandoned in favour of mobility, and it is now suggested that the British V-bomber fleet could be equipped with American *Sky Bolt* air-to-surface missiles, or the *Blue Streak* replaced by atomic submarines carrying the American *Polaris*.

For the time being, at any rate . . . But although Britain has temporarily decided to resort to American missiles for her defence, in the long run she must think of her own industry and persevere in her attempts to create British weapons—or, perhaps, European ones . . .

*

It seems possible, and indeed highly probable, that the British Minister of Aviation, on his recent visits to Paris and Bonn, discussed *Blue Streak, Blue Steel* and the European deterrent strategy in general with his colleagues Messmer and Strauss. But there can be little doubt that, when Duncan Sandys took up his pilgrim's staff, his motives were less strategic than economic. After the recent mergers in the British aircraft industry, the new large concerns are, if anything, even more hungry for contracts than their predecessors. And no industry can live by strategic concepts alone. It might therefore not be far wrong to say that the "top secret" label on Duncan Sandys' talks in Paris and Bonn covers the intent to seek a common market for the British and continental European industry.

The continental European industry is at present engaged in a series of common projects —F-104, G. 91, *Transall, Atlantic*, guided missiles, including the *Hawk*, tanks etc.—in which Britain is only partially, if at all, concerned.

Promising civil and military areas in which Britain could join with other countries are: a single-seat V/STOL combat aircraft, on which Britain has already done much useful preliminary work and which could be powered by British engines; a common blind landing system for all European airports; and other air traffic control and airspace surveillance systems. It seems somewhat doubtful, however, whether, in view of a number of technical difficulties and the strained financial situation of many of the airlines, a supersonic airliner is already under serious consideration.

Nevertheless, Duncan Sandys appears to be determined and energetic in his efforts to unite the British aircraft industry in a profitable association with its continental sisters. The success of the talks would, however, be completed by the participation of Italy. For in the past decade the European aircraft industry has learnt that its chances of survival are slim if it remains in hermetically sealed national compartments. In the long run, it can exist only as an indivisible whole.

Air Photography and Aerial Survey

The Aerial Photograph and its Uses in Mapping, Technology and Research

By Prof. H. Kasper, Heerbrugg, Switzerland

One hundred years ago the French photographer and balloonist, G. F. Tournachon ("Nadar"), took the first aerial photograph of Paris from a balloon. His contemporaries poked fun at this beginning of scientific photography from the air, and a cartoon by the famous Honoré Daumier has now become a valuable document *(Fig. 1)*. The methods recorded by Daumier have changed a little since Nadar's time. The balloon has been replaced by modern aircraft, and the simple hand camera has been developed into a fully automatic measuring camera for serial exposures, with high-performance lenses and film magazines for taking several hundred pictures.

Fig. 1: The first aerial photograph of Paris being taken by the balloonist G. F. Tournachon ("Nadar"), as caricatured by H. Daumier.

Nevertheless, the principle remains the same. The Brockhaus encyclopaedia gives the following simple definitions of the subject: "*Aerial photograph:* The photographic image of a part of the earth's surface, usually taken from an aircraft. According to the inclination of the camera axis, a distinction is made between vertical, high oblique, low oblique and horizontal photographs. The *vertical* photograph gives the best picture of the terrain, being most similar to a map and having almost uniform scale for flat country. The *oblique*, on the other hand, gives a perspective presentation in which the foreground is emphasized"; and "*Air survey* (Photogrammetry), a branch of surveying in which topographical maps are prepared from landscape photographs taken from an aircraft."

This is exactly what Nadar tried to do a hundred years ago. What is the position today? Air photographs, nearly always oblique perspectives, are taken for the illustrated papers, for reports on natural catastrophes and as supplements to descriptions, and almost every pamphlet advertising holiday resorts makes use of air photos. Of far greater importance, however, is the use of aerial photographs, as perspectives or for measuring purposes, in many branches of applied science, such as geographic and cartographic research, the economic development of large unexploited areas, town and regional planning, highway and railroad construction, hydraulic engineering including irrigation and drainage for agriculture, re-allotment of property and cadastral surveys, oil prospecting and military reconnaissance. Finally, in statistical subjects varying as widely as traffic analyses and parking problems, the assessment of damage resulting from floods *(Fig. 2)*, forest fires, frost, wind, landslides, avalanches, and bombing, the air photo provides a lasting record of factual evidence.

Nevertheless, the most widespread use of aerial photographs today is in the *preparation of maps*. No official cartographic institution could dispense with the help of the air photo. Large-scale plans to scales of 1:500, 1:1,000 to 1:2,500 for cadastral purposes, large-scale general plans to 1:5,000 and 1:10,000 as economic maps and as the basis for technical projects, topographic maps to 1:20,000 to 1:100,000, and small-scale general topographic maps to 1:200,000, are all prepared from aerial photographs varying from 1:4,000 to 1:120,000 in scale.

In view of the far-reaching influence of aerial photogrammetry on many branches of research, economic investigations and engineering construction, and since detail surveys today rely on the aerial photograph, it is both interesting and valuable to learn more about aerial photography and its possibilities.

Some general remarks: When used for illustration the oblique photograph *(Fig. 3)* need generally be no more than an attractive perspective view. On the other hand, much more is expected in terms of content and accuracy of a scientific aerial photograph when it is to be used as a source of information or measurements. The scientific air photo should be taken so as to resemble a map as closely as possible. This condition is best satisfied by the vertical photograph *(Fig. 4)*. All other types of photograph are, by comparison, of minor importance in photogrammetry. Similarity to the map and the instructive nature of the presentation are not the only

Fig. 2: Four days after typhoon Vera struck Nagoya, Japan, this oblique photograph on infrared film was taken from a height of 4,000 m, to determine flood damage. *(Asia Air Survey, Tokyo).*

characteristics of a good aerial photograph: easy recognition of details is of decisive importance in economic uses. From the air photo it is possible to plot only those details which are recognizable and measurable. The whole effort of the aerial photographer must therefore be concentrated on attaining the *best picture quality possible*. And it is clear from the foregoing statements that the lenses of photogrammetric survey cameras must have exceptionally high optical qualities and that the greatest of care must be taken in all stages of the photographic process.

Compared with landscape photographs taken on the ground, terrain contrasts seen from the aircraft are very weak. The optical system of an air camera must therefore have exceptionally high resolving power in order clearly to reproduce sufficient detail on the terrain. The quality of a topographical map suffers, for example, if in the aerial photograph a house cannot be distinguished from a large block of stone.

The geometry of the vertical photograph: Strictly speaking, a vertical exposure is an aerial photograph taken with the camera lens axis in the vertical or plumb-line position. In practice, a picture is still regarded as a good vertical photograph when the angle between the plumb-line and the lens axis (the nadir distance) is less than 2°.

With a distortion-free lens, the photographic image is a *genuine central perspective*, whereas the map is an orthogonal projection *(Fig. 5)*. The problem of measurement in photogrammetry, seen geometrically, is that of converting the central projection of the photograph into the orthogonal projection of the map. The scales at which photogrammetric maps are plotted range from 1:200 to 1:200,000 depending on purpose. Picture scale and area per photograph must be suited to the map scale.

It can be seen from *Fig. 6* that picture scale M is given by the ratio of focal length f of the camera to height of flight above ground, H:

$$M = \frac{1}{m} = \frac{f}{H} = 1 : \frac{H}{f}$$

m—the reciprocal of M—is known as the scale number. In this important formula for exposure relationships, H and f must be in the same units, e.g., in metres. If a picture is taken with a camera of 15 cm focal length at 1,500 m altitude, the scale will be 1:10,000. Altitude and focal length can be selected in order to obtain a given picture scale.

Minimum altitude is usually limited to about 300 metres by image movement due to flying speed. The upper limit is determined by atmospheric conditions or the aircraft ceiling, which might be 12,000 to 15,000 metres. In practice, however, flights are mostly between 600 and 6,000 metres above ground. Focal lengths are limited in number, and the same applies to picture sizes. This standardization makes for better utilization of the plotting instruments and photographic material.

Nowadays, most photographs are taken on 24 cm (9½ in.) film, but 19 cm (7½ in.) film is much favoured in Europe. In Switzerland, plate cameras for 15 cm × 15 cm (6 in. × 6 in.) plates are used for high-precision large-scale photography. The formats of the actual pictures corresponding to the above sizes are 9 in. × 9 in., 18 cm × 18 cm and 14 cm × 14 cm.

Fig. 3: Accentuated foreground and attenuated background are the characteristics of this oblique photograph of the Wiedbach Autobahn bridge between Frankfurt and Cologne. *(Aeroexploration Frankfurt.)*

Fig. 4: Vertical photograph of a junction on King George Highway, Vancouver. Flight altitude 180 m (600 ft); original negative scale 1 : 1,200; Aviogon 15 cm (6 in.) lens. *(P.S.C. Vancouver.)*

The focal lengths of the photographic lenses which are made in Switzerland for these three formats are 15 and 9 cm (6 in. and 3.5 in.), 21 and 11.5 cm (8.25 in. and 4.5 in.), and 17 and 10 cm (6.7 in. and 4 in.) respectively. The 17 cm and 21 cm Aviotar lenses have a maximum angular field of 60°, while the 10 cm and 15 cm Aviogon lenses have an angular field of 90°, and the 9 cm Super-Aviogon lens has a 120° angular field. *(Fig. 7)*. The most important universal lens today is the 90° wide angle lens with 15 cm (6 in.) focal length. The newly-developed 120° super wide angle lens with 9 cm focal length was designed in Switzerland especially for small scale cartography. Both lenses are for the 23 cm × 23 cm format.

Figure 8 shows a universal camera with interchangeable lens cones for a focal length of 15 cm and interchangeable film magazines. *Figure 9* shows a super wide angle camera (9 cm) with its daylight loading cassette. The short focal length produces a smaller picture scale, but at the same altitude covers an area three times as great as the 15 cm camera.

A modern aerial camera has the following features: A high-performance lens with adjustable aperture and a between-the-lens type shutter for short duration exposures down to 1/300 sec is rigidly connected to a focal plane frame with measuring (fiducial) marks in the corners or mid-sides; these marks are necessary during the measuring process for reconstruction of the relationships existing at the instant of exposure. The fiducial marks are reproduced on the film with each photograph. The film must be held flat against the focal plane frame for each exposure: this is ensured by a pressure plate with suction equipment. Interchangeable magazines contain a supply of roll film for 200 exposures. Interchangeable filters are affixed in front of the lens. For colour pictures, a light ultraviolet filter is used; for panchromatic material a light or dark yellow filter, in haze a light orange, and for infrared photographs the filters vary from light to dark red.

In order to ensure complete photographic cover of the terrain, it would be sufficient to produce, say, parallel strips of photographs, overlapping 20 to 25 percent in each direction. However, for stereoscopic measurement the

Fig. 5. With a distortion-free lens the aerial photograph is a genuine central projection, while the map is prepared as an orthogonal projection.

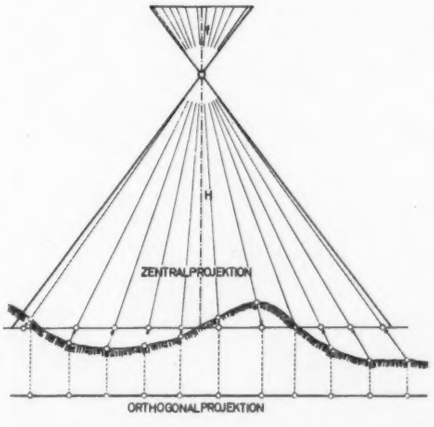
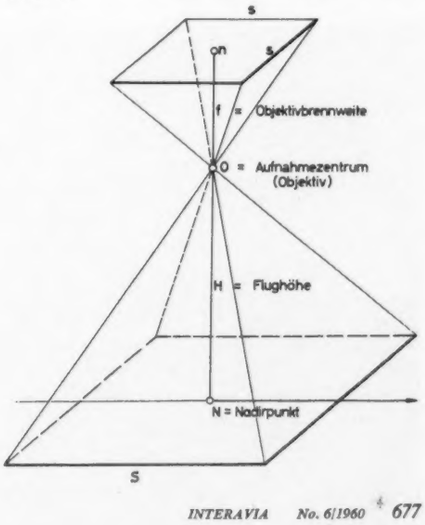


Fig. 6: Diagram showing the determination of picture scale from flight altitude above ground (H) and lens focal length (f).



Aerial work

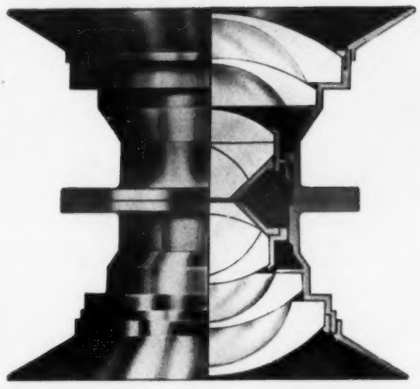


Fig. 7: The Aviogon type of lens is the most widely used high-performance lens in aerial photogrammetry; it has minimum distortion, high resolving power and gives clear pictures right into the corners.

Fig. 8: Wide angle aerial camera with the Aviogon lens, mounted in a Do 27 of Swissair Photo Ltd.

Fig. 9: Super wide angle camera (daylight-loading cassette raised) with the 120° Super-Aviogon lens for small scale cartography.

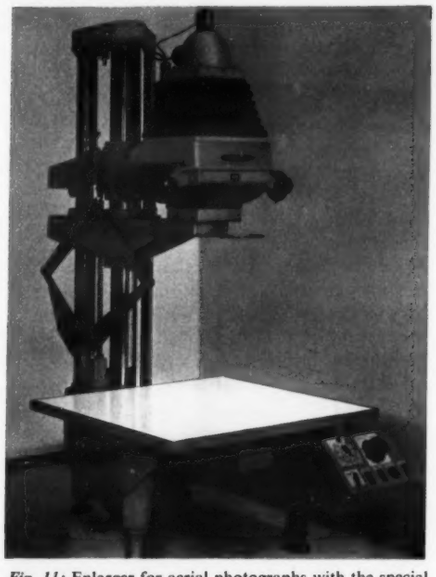
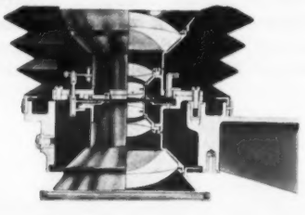


Fig. 11: Enlarger for aerial photographs with the special "Reprogon" lens: automatic focussing, up to 7 times enlargement.



whole area must have complete and *double photographic cover*. The pictures are taken in series so that each photograph overlaps the previous one by not less than 60 percent in the flight direction; such a series is known as a strip. Adjoining strips must have a mutual lateral overlap of 20 to 25 percent. An overlap regulator—which is very simple to set—controls the shutter release so that exposures with the desired overlap are made automatically. The complete cycle of operations is fully automatic: film suction is released, the film is wound further and then re-flattened on the focal frame while the shutter is rewound. The camera is supported on the aircraft floor in a mount which can be levelled. Below it, a port is cut out of the fuselage.

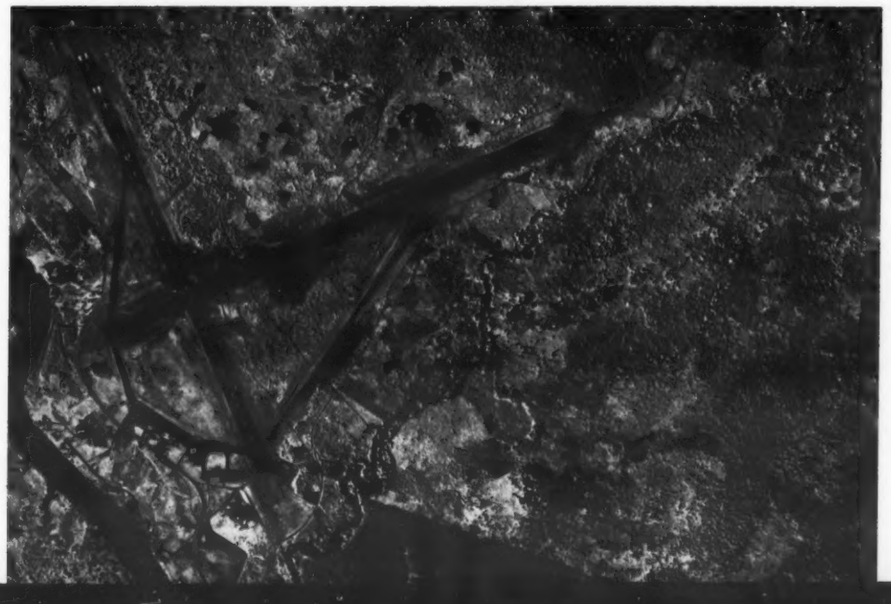
Slow-flying aircraft, such as the single-engine Do 27 and the twin-engine *Twin Pioneer*, are particularly suitable for low-level photographic flight. Two cameras can be mounted together without difficulty in the *Twin Pioneer* for special photography, e.g., panchromatic and infrared. A multi-purpose aircraft with good all-round navigator visibility is the Piaggio 166.

Photo flights are best made in fine weather with no clouds, or with even a high cloud cover. Other considerations for photography are the latitude, time of year and day, the meteorological and atmospheric conditions, the character and colour of the terrain, the flight altitude, and the particular properties of the camera, the filter and the film. Since the shadow area should be as small as possible, flights are usually planned for the midday hours. Over mountainous terrain, the best results are often obtained with the diffused light resulting from full, high cloud cover. In some parts of the tropics photo flights must be made in the diffused light of early morning, because of the low clouds or impenetrable haze which appear later in the morning.

In general, *panchromatic film* with increased red sensitivity is used for aerial photography. For special purposes, the red sensitivity is extended into the *infrared* range of the spectrum, because certain objects have reflective properties appreciably different in infrared from those in the visible range of the spectrum. In this way it is possible to identify in the aerial photograph various deciduous tree types which are not distinguishable when the visible light range is used. Concrete roads and water surfaces are less reflective in the infrared, and appear in black on the positive print, although in the panchromatic range their high reflectivity causes them to be shown in white on the positive *(Fig. 10)*.

More colour film is being used now as a means to facilitate air photo interpretation. Relatively shallow off-shore underwater forms for example, are very impressive in the colour pictures used in coastal surveys. Often, however, neither panchromatic, infrared nor colour film is suitable for the positive identification of some tree types in large forest areas. When these trees cannot be distinguished from their surroundings by shape or visible colour, a different colour spectrum may be of assistance, e.g., infrared. But even infrared film may fail, since it is only a black-and-white film. This is due to the effects of a combination of grey shadow tones on the slopes, which can partly or wholly hide the distinguishing characteristics of different sorts of trees, making interpretation inaccurate or even impossible.

Fig. 10: Infrared photograph of a Liberian airport. The concrete runways and watercourses show as black; trees are lighter in tone. Original scale 1 : 17,000, flight altitude 2,500 m.



In the Soviet Union, a special film known as Spektrozonal film is used instead of infrared for overcoming these difficulties. The reflection differences in a particular spectral range are reproduced by strong changes in colour. For instance, one type of tree will appear as purple to violet, next to other types recorded on the picture in orange or yellowish green. The spectral range of the various reflectivities of the tree species being investigated are determined prior to photography with the help of an aerospectrophotometer. Spektrozonal film corresponds roughly to the Zeiss-Ikon "Enttarnung" (camouflage penetration) Film and the American Camouflage Detection Film by Kodak. Nevertheless this film appears to have found favour only in the Soviet Union.

Regarding film material, it should be mentioned that the film base should be as stable as possible against warping and dimensional change; triacetate and polystyrol foil are most used today. After the flight, films are processed in automatic developing equipment. The greatest of care is necessary at this stage. In most cases, glass diapositives are made for measuring or mapping use. These, and contact paper copies, are prepared in a contact printer with parallel light source. Strong contrasts in the negative are balanced out in special copying printers by electronically controlled illumination.

In addition to the vertical aerial photograph auxiliary pictures can be made to establish the deviation of the camera axis from the plumb. These photo aids are either horizon pictures, or photographs of the position of a gyroscopic axis, or sun pictures. Another instrumental aid is the *statoscope* for measuring the relative height differences of the exposure positions, i.e., a differential barometer which gives the differences in atmospheric pressure in the flight path, registering them at the instant of exposure. In recent years a radar-principle profile recorder has been developed in Canada, which plots the flight path profile.

Prior to the photo flight, an accurate flight plan is worked out on the basis of map or of small-scale photographs previously taken for the purpose. Flight altitude and longitudinal and lateral overlap are chosen according to the terrain and the purpose of the survey flight. The utmost accuracy is required of the crew in the navigation of a survey aircraft. Straight, parallel and level flight paths, following an accurately prepared plan, are the aims of every photo flight. For large-scale cartographic purposes, *pin-point* accuracy is always required. Gaps in photography must be avoided since patching is costly in both time and money.

The air photos are not used only as contact prints and dispositives. They can also be enlarged to a predetermined scale for easier and clearer examination. The enlarger *(Fig. 11)* must have a very good lens and a highly actinic light source, giving even distribution over the negative, so that the enlargement is sharp and clear in all details. Good air photos can be satisfactorily enlarged 6 to 8 times.

By enlarging the pictures to a uniform scale, and if necessary rectifying them to correct the nadir, it is possible, with correct assembly, to make an even-scale *controlled mosaic* of flat country. With large height differences in the terrain, scale differences will occur; such an assembly is called an *uncontrolled mosaic (Fig. 12)*.

Single pictures, photo-maps and mosaics cannot, however, reproduce terrain in relief. An illusion of relief, based on experience of three dimensional estimation, is created by the nature of the vegetation, the play of light and shade, the perspective of buildings, etc. This illusion can nevertheless be very misleading; but for the area common to two overlapping aerial photographs *(Fig. 13) genuine*, three-dimensional observation is possible by viewing the photographs with a *mirror stereoscope (Fig. 14)*. The two adjoining pictures must be placed so that the centre of each and the corresponding image on the other picture, are in a straight line parallel to the eye-base of the stereoscope.

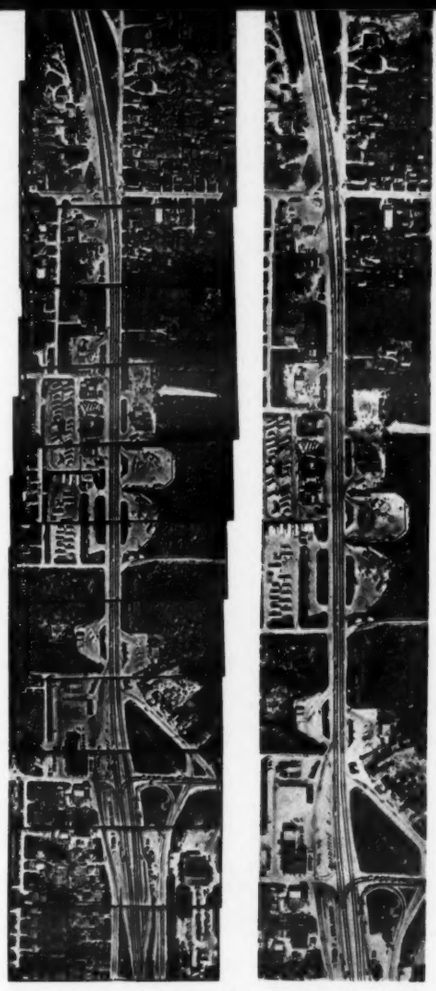


Fig. 12: Mosaic of air photos. Left, the pictures (1 : 1,200); right, the mosaic, slightly enlarged (1 : 1,000 in the original).

A three-dimensional view of the terrain can also be achieved by means of the *anaglyph method*. The two overlapping parts of a picture pair are copied one over the other in complementary colours, usually in blue-green and orange. The overlap area is seen in relief when viewed through red-blue spectacles.

Interpretation of an aerial photo begins with examination of the content. The first step is known as *photo-identification*. Either contact prints or 4—6 diameter enlargements are

Fig. 13: Two successive photographs, overlapping by 60%.

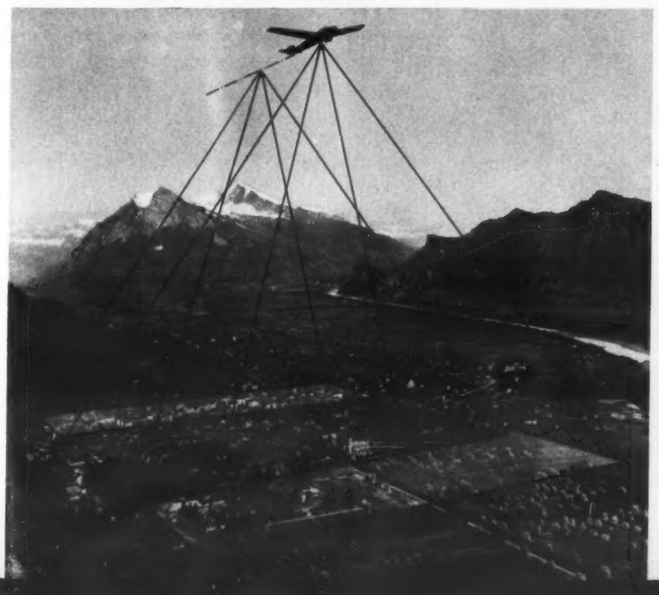
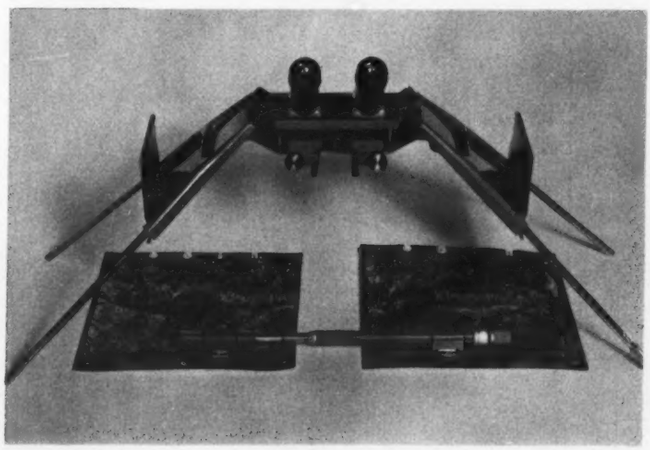


Fig. 14: Overlapping pictures like these are seen under the mirror stereoscope as a three-dimensional model.



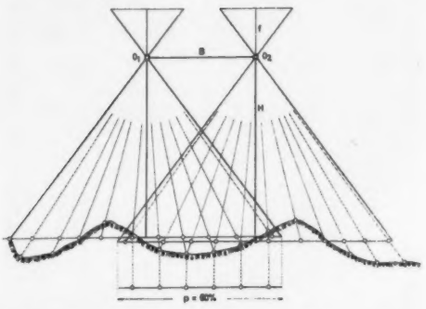


Fig. 15: Reconstruction of the ray path for two overlapping aerial photographs.

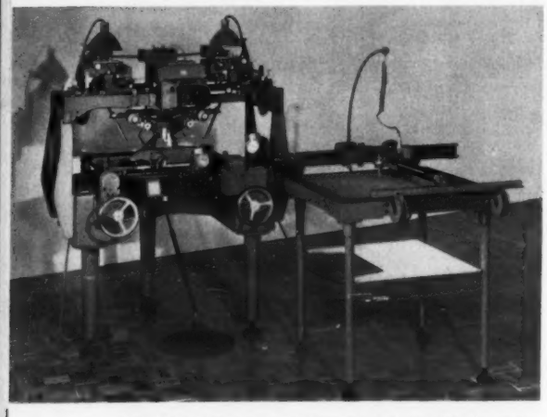


Fig. 16: Wide angle Autograph for small-scale cartography.

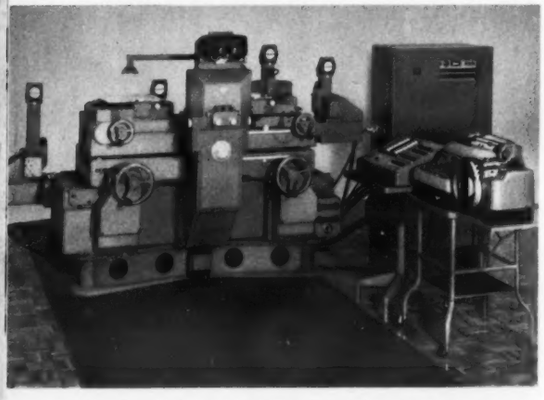


Fig. 17: Precision Stereocomparator for the measurement and automatic recording of picture coordinates, with micron accuracy.

Fig. 18: Working on a topographical plotting instrument.

used, under a stereoscope. The second step is *photo-interpretation,* the understanding of the significance of what can be seen in the photographs. A simple example illustrates the difference between identification and interpretation:

1. Identification:

A road with vehicle tracks.

2. Question:

Why do the tracks cut some left-hand bends, while in other similar left bends they are in the centre of the road?

3. Answer by interpretation:

At a bend which is not cut there is probably an obstruction, such as a bush, which limits visibility just at the point where a driver might normally be tempted to cut the bend.

Quite apart from the military significance of the air photo as a reconnaissance aid, photo interpretation plays an important part in geology (e. g. in oil prospecting), in forestry, in agriculture, and in numerous other fields.

Simple instruments such as the mirror stereoscope are not adequate, however, for the *preparation of accurate contour maps.* Instruments must be used in which the photographs and their projection centres can be placed in the same relative positions as were occupied at the instant of exposure, and the path of the projection rays of the two consecutive exposures must be reconstructed *(Fig. 15).*

The projection rays to a given terrain point, photographed from two successive positions, intersect at a model point. Projections of all such points combine to produce a "model" of the terrain photographed. The scale will be the same as the ratio of the distance between the projection centres in the plotting instrument to the distance between the actual exposure points during flight. In the plotting instrument, the projection rays can be represented by light rays or by mechanical space rods and computing gears.

The space rods or projection rays are combined with a floating mark (or pair of measuring marks) in such a way that the mark appears to rest on the optical model surface when the corresponding pair of rays intersects in the correct position in space.

The measuring and plotting process starts with the *relative positioning* of the two pictures. This results in the formation of a model which must be positioned absolutely in relation to geodetically known ground points. Although three such points are sufficient for the scale and position correction, in practice four or five control points are used.

Figures 16 to 19 show photogrammetric plotting instruments which are made in Switzerland. With these, the coordinates of any required terrain points can be determined and recorded automatically. The plot can be made on a given scale, with contour lines, on the drawing table; terrain profiles can be measured, and all topographical details recognizable in the photographs are easily transferable to the map.

TABLE I

Details relating to a wide angle lens with focal length of 6 in. (15 cm), picture format 9 in. × 9 in. (23 cm × 23 cm)

Picture Scale M = 1 : H/f = 1 : m	Flight Altitude above ground (Metres)	Terrain area per picture S^2	Side S of terrain square (Metres)	Base B for p = 60% (Metres)	Signal diameter $\frac{m}{400}$ (cm)	Attainable height accuracy: very well defined points (cm)	terrain points (cm)	contour lines (cm)
1 : 3,000	450	45 ha	675	270	10	± 6	± 10	± 15
4,000	600	80 ha	900	360	15	± 8	± 12	± 20
5,000	750	125 ha	1,125	450	15	± 10	± 15	± 25
6,000	900	180 ha	1,350	540	15	± 12	± 18	± 30
8,000	1,200	325 ha	1,800	720	20	± 16	± 25	± 40
10,000	1,500	500 ha	2,250	900	25	± 20	± 30	± 45
12,000	1,800	730 ha	2,700	1,080	30	± 25	± 35	± 55
15,000	2,250	11 km^2	3,375	1,350	40	± 30	± 45	± 70
20,000	3,000	20 km^2	4,500	1,800	50	± 40	± 60	± 90
25,000	3,750	30 km^2	5,625	2,250	60	± 50	± 80	± 110
30,000	4,500	45 km^2	6,750	2,700	75	± 60	± 90	± 140
40,000	6,000	80 km^2	9,000	3,600	100	± 75	± 120	± 180
50,000	7,500	125 km^2	11,250	4,500	120	± 90	± 150	± 230

Fig. 19: Precision Autograph with electronic coordinate recording in typescript and on punched tape.

The accuracies attainable from different flight altitudes, and the areas covered per photograph, are given in *Table I.*

The altitude for any particular job is chosen according to the accuracy required. In *Table II,* scales and altitudes are given for the super wide angle (120°) lens which is used for small-scale cartographic photography. These figures will ensure the necessary plotting accuracy; more important is clarity of the picture details which must be shown in the map.

TABLE II

Data for the super wide angle camera with 9 cm focal length, picture size 9 in. × 9 in. (23 cm × 23 cm)

Picture scale M M = 1 : H/f = 1 : m	Flight Alt. above ground (Metres)	Terrain area per picture S^2 (km^2)	Side S of terrain square (km)	Base B for p = 60% B = 0.4 S (km)
1 : 20,000	1,800	20	4.5	1.8
30,000	2,700	45	6.7	2.7
40,000	3,600	80	9	3.7
50,000	4,500	125	11	4.6
60,000	5,400	190	14	5.5
80,000	7,100	320	18	7.3
100,000	9,000	520	23	9.1
120,000	10,800	730	27	10.5

Note: 1 km = 0.6 miles approx.
10 km^2 = 3.9 sq. miles approx.
1 ft = 30.48 cm
100 m = 330 ft approx.
10 ha = 25 acres approx.

It should be mentioned that with some plotting instruments, it is possible to extend mapping over areas lacking geodetic control points. This bridging process is known as *aerotriangulation. Fig. 21* shows the principle of a simple strip triangulation. However, aerotriangulation includes not only the strip procedure, but also the treatment of whole blocks by combining adjoining strips, which ensures that the values obtained for the triangulation points thus fixed have greater reliability.

Photogrammetry has been adopted as the modern means of survey throughout the world. Modern mapping without photogrammetry is unthinkable. In some countries, aerial photogrammetry is mainly a government activity; in others, it is in the hands of private firms, but the scope of this paper does not include an analysis of the forms of organization.

Facilities for training in photogrammetry are offered by technical colleges and universities in many countries. Particular mention should be made of the *International Training Centre for Aerial Survey,* in Delft, Holland *(Fig. 22)*. Here, specialist education is given for engineers and technicians in photogrammetry and photo interpretation. The courses last one to two years, and are attended by students from all parts of the globe. The official language of instruction is English. The ITC Delft is well equipped with instruments of all types, and has very modern lecture theatres and work studios, as well as a students' hostel. These facilities make the interesting profession of the photogrammetrist accessible to a very wide public. ↔

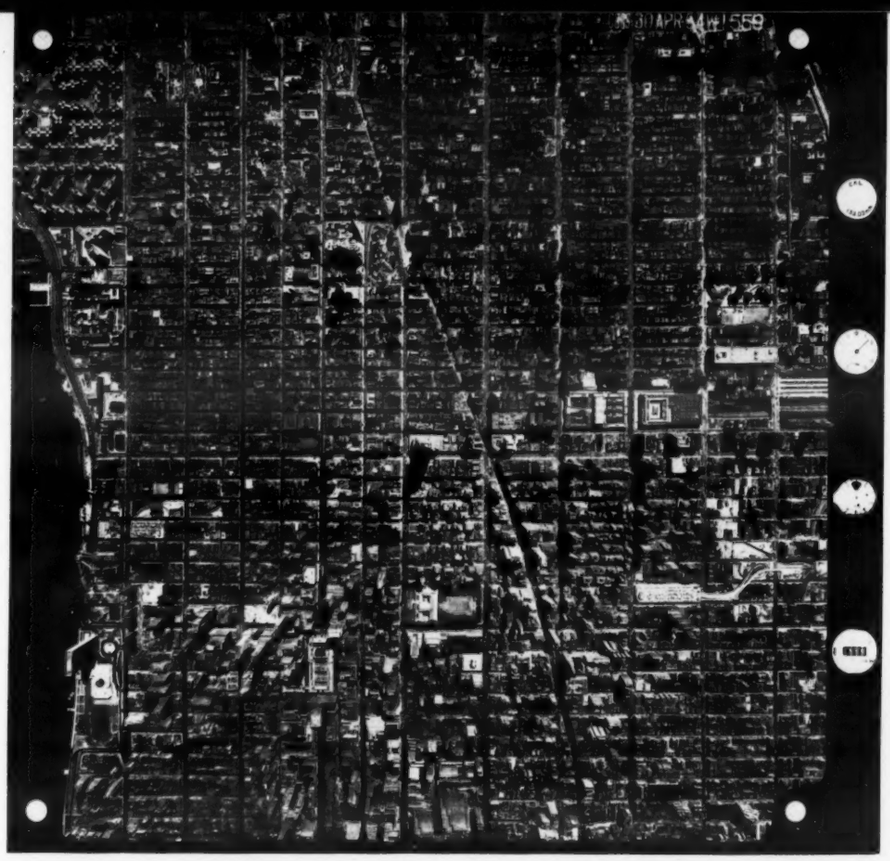


Fig. 20: Geometrical New York: vertical photograph of the centre of Manhattan taken with a WILD RC-5 camera and wide angle Aviogon lens, f: 5.6, focal length 153.02 mm; flight altitude 2,300 m, original negative picture scale 1 : 15,000. *(U.S. Coast & Geodetic Survey.)*

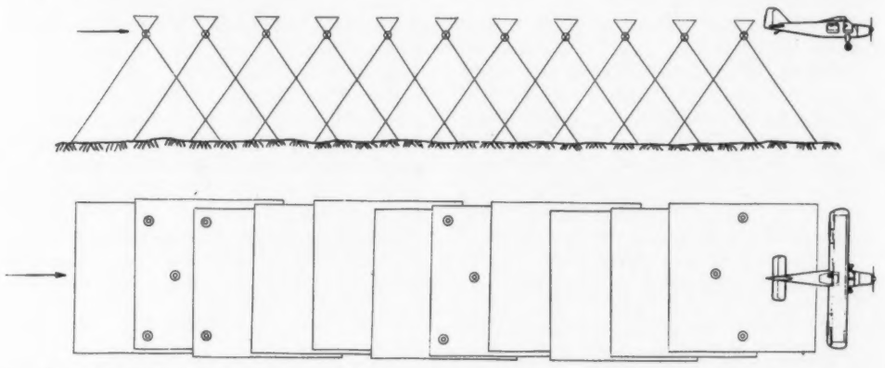


Fig. 21: The principle of strip triangulation.

Fig. 22: Main building of the ITC, Delft, where students from many countries, especially from less developed States, are trained in photogrammetry.

Air Survey in Switzerland

By E. K. Barnes, Interavia, Geneva

As much of the contents of this issue of *Interavia* are concerned with the topic of aerial work, it is a suitable opportunity to review the subject of air survey as it is carried out in Switzerland, and to report on the activities of an individual company engaged in this type of work.

Two Federal departments exist which control and coordinate surveys throughout the country and are responsible for all cartographic work on a national basis. These are the Federal Topographic Service (Eidgenössische Landestopographie) headed by Mr. Ernst Huber, and the Cadastral Service (Schweizerische Vermessungsdirektion) directed by Dr. Hans Härry. Both these Services have their aircraft stationed at the military base of Dübendorf near Zurich. The survey fleet consists of a *Twin Pioneer* and several Beech 18s which are flown by Regular Air Force pilots of the Überwachungsgeschwader.

The Federal Topographic Service is responsible for the production of all maps and charts for civil and military use. The Cadastral Service on the other hand is responsible for land registration in terms of legal title to ownership and for the provision of plans detailing property boundaries. For this reason it comes within the control of the Department of Justice and Police while the Topographic Service lies within the framework of the Department of Defence.

Together with the work being carried out by the military aircraft operated by these two Services, a private company is also engaged in considerable survey flying, much of it being on behalf of one or other of these agencies.

This company is Swissair Photo, and as its name implies it is a subsidiary of the Swiss national airline Swissair, but operates as a completely separate entity. Small in size at the moment, it has rapidly developed an extensive reputation, and in the coming years it will play an increasing part in the field of air survey not only in Switzerland but internationally. Though a subsidiary company, it is controlled by a separate managerial board and is directed by Dr. Karl Weissmann, a specialist in photogrammetry.

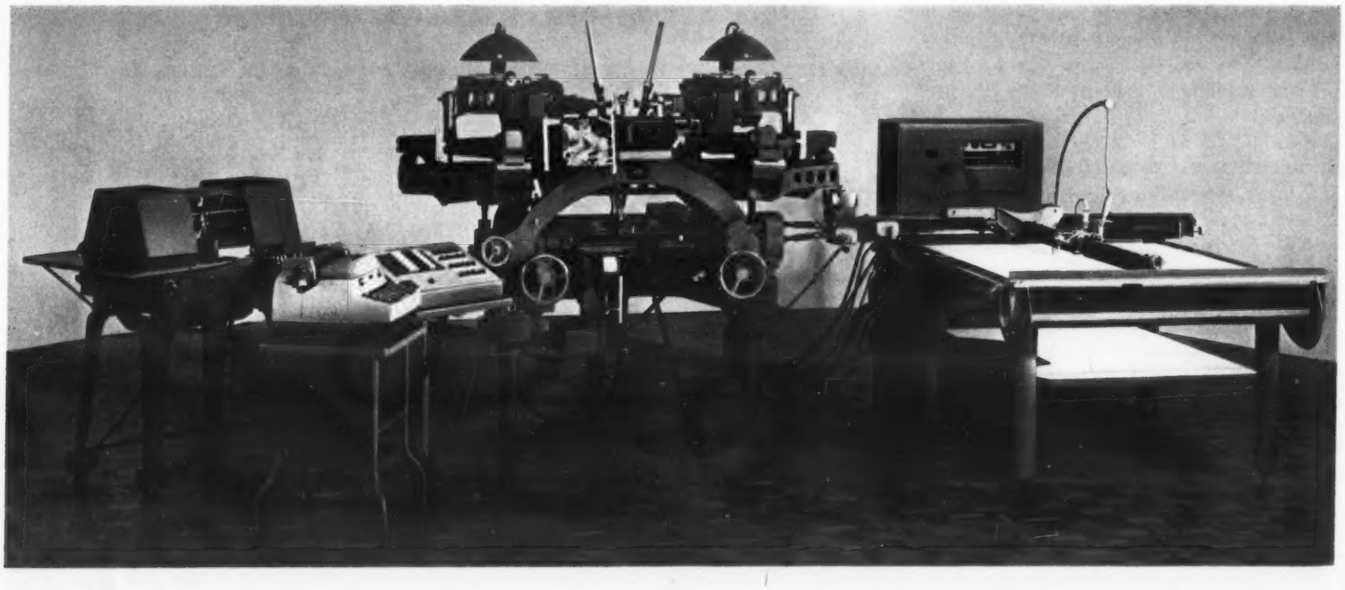
The origins of the company date back to 1931 though it has only existed in its present constitution since 1958. In that year the requirement for air survey in Switzerland had reached such proportions that the present directors decided on the provisional establishment of a company to handle some of this work. The period during which the company existed on this provisional basis was employed for evaluation. Operational methods were studied, and the most satisfactory types of equipment sought for. First on the list of priorities was the selection of a suitable aircraft for the work in mind. In this respect the geographical nature of Switzerland poses special problems. The advantages of air survey are well illustrated in a country where much of the terrain would demand the utmost agility from a human ground surveyor equipped with theodolite and chain. Similar demands are made of an aircraft which is intended to operate in mountainous country, and the final choice fell upon the Dornier Do 27.

It has been found in the course of operations that this machine possesses the qualities of handling and manoeuvrability which make it an ideal camera vehicle. The high wing configuration offers uninterrupted visibility for the pilot in the course of the camera run, and the size of the rear cabin is adequate for the movements of the operator in flight. The speed range and turning circle enable the pilot to penetrate steep and narrow valleys and permit him to turn within the valley walls in safety. The STOL capability of the Do 27 also offers the maximum safety margin in the event of a forced landing in mountainous country.

Once the choice had been made and the aircraft procured, some minor modifications were carried out to the airframe to permit the camera to be installed; operations were then commenced on a small and experimental scale. Today Swissair Photo is undertaking a steadily increasing volume of work, much of it being for one or other of the Federal Services.

The type of work falls into three main categories. There is at present being carried out in Switzerland a National Highway scheme which is in process of both reconstructing and developing the highway network. This has called for a

The WILD A 8 Stereo-Plotting machine used for photo evaluation. On the left are the units of the electric coordinate printer including the input connection for tape or card punch. To the right of the machine stands the large plotting table with the plotting pen mounted on the carriage.



considerable amount of survey both for proposed new roads and also for the extension of existing highways. The work is being carried out on a Cantonal basis under an overall Federal plan. Swissair Photo has undertaken a considerable part of the survey flying and photographic analysis on behalf of many of the Cantonal authorities in connection with this scheme.

The planning and survey for hydroelectric schemes has also provided opportunities for air photography. In this connection the capabilities of modern instrumentation are utilized to the full. With present day contour plotting machines there is little likelihood of an error resulting in the building of a reservoir that does not fill or which only collects half its intended capacity.

A third type of survey flying which the company has been engaged in is on behalf of the Cadastral Service. This work has also been undertaken under the various Cantonal and Town authorities. This survey is in connection with a land reallocation scheme which is at present in hand to improve the return from agricultural land. As much of the land in Switzerland is owned and divided in small parcels—a method of land distribution which is a relic of feudal ownership and strip cultivation—it is intended to effect a redistribution among landowners which will result in larger and more compact holdings. This will be both beneficial to the landowners themselves in terms of more economic working conditions and will also remove many anomalies in distribution which have existed over the years.

While it is almost impossible to generalize and to describe a typical photographic contract, a number of factors apply to all survey photography. Apart from weather conditions—possibly the greatest handicap—the season is also a matter of considerable importance. In Switzerland the ideal period for photographic survey is in early spring after the snow has disappeared. At this time of the year the foliage is not sufficiently advanced to obscure ground detail, and at the same time the chances of good flying weather with reasonably stable air are more likely. It is a measure of the accuracy of the contouring plotters that the foliage in forested areas will result in contour error on the finished maps equivalent to the height of the trees.

The same requirements hold good for the production of cadastral surveys. Prior to the photo flight the land boundaries in question have to be marked out on the ground. This is done by stakes driven into the soil carrying a piece of white cardboard about a foot square horizontally on top. The positioning of these stakes has to be carried out in the presence of the neighbouring landowners so that agreement as to the boundaries is obtained immediately. The extent of one of these projects can be judged from the number of stakes required to mark the area; as many as 20,000 have been required for some surveys. In European weather conditions it is a considerable feat to mark an area with such a number of markers and still have good enough flying weather to carry out a successful photographic trip. If bad weather intervenes the marker cards become limp and sodden and can no longer be distinguished on the film. Bad weather is not the only foe in this type of operation; small children are equally capable of rendering the survey abortive.

The flying requirements for photographic missions are well known: accurate navigation and steady course, height and speed during the run. In mountainous country there are the added difficulties from turbulent air and freak wind conditions. Many of the photographic sorties flown by Swissair Photo are carried out in these difficult conditions; it should also be borne in mind that although the flights are carried out at medium altitude above ground level, the altitude in relation to sea level is considerable; Zurich Airport for example lies 1,300 feet above MSL. This results in lower engine performance and reduced ease of handling, together with the necessity for oxygen equipment.

The camera operator at work in the Do 27. By adjustment of a spiral graticule in the optical sight a signal is passed to the automatic control unit which then regulates the speed of frame exposure to give the desired overlap. The tube by the operator's left hand supplies vacuum pressure to hold the film flat at the moment of exposure.

While the actual piloting difficulties remain, the development of semi-automatic camera and camera control equipment has greatly reduced the workload for the operator. Swissair Photo uses the WILD RC 8 camera in its aircraft, together with an automatic timing control. To use this the operator sets the amount of overlap desired between successive exposures and by means of an optical sight on the camera body tracks prominent ground features in the field of view. The adjustment of the sighting head gives an indication of the aircraft ground speed which is passed to the control unit. This unit then automatically calculates the speed of frame exposure repetition to give the required overlap.

As is always the case with aerial photography, the amount of time required to take the photos is only a small proportion of the complete task. The photos, after development in the company's dark rooms, then pass to the interpretation section. Here a large battery of high precision analysis instruments is used to derive the data required from the survey.

In the analysis department the main item of equipment is the WILD A8 Stereo-Plotting machine. This precision instrument is used for the evaluation of vertical photographs taken for mapping at scales up to 1:2,000. By means of stereo projection the machine enables the operator to plot and trace the complete contour lines on the map by tracking a floating spatial point over the ground picture. The resulting contours are very complete and accurate even over the most rugged terrain.

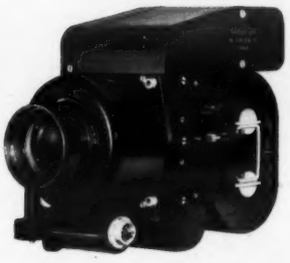
For cadastral surveys an electric coordinate printer can be fed from the machine for the registration of boundary corners in numerical symbols. These coordinates can then be stored by means of a punched card or similar recording system.

Since its formation Swissair Photo has been carrying out many varieties of survey photography and evaluation at a steadily accelerating tempo. Having established the means, the policy of the company is to extend their applications. To date all the work has been carried out in Switzerland; the next step will be to extend operations overseas. In this respect a Swiss company finds itself in a peculiarly advantageous position. The traditional neutrality of Switzerland makes the employment of a Swiss organization particularly attractive to the Governments of many underdeveloped but developing countries where there is a great need for survey to assist in the development of natural resources. Wishing to maintain a balance between the Powers of East and West and not desiring to be drawn into any influential partnership, these Governments welcome the opportunity to employ a neutral aid. With this prospect in view it should not be long before aircraft bearing the registration HB and wearing the red and white livery of Swissair Photo commence operations in many of the remote unsurveyed areas of the world. ✦✦

The Do 27 operated by Swissair Photo. With its stability in flight and ample cabin accommodation this has proved an ideal camera vehicle.

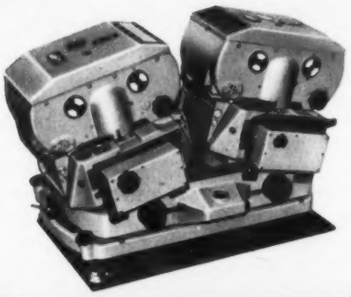
Some Typical Tools for Air Survey

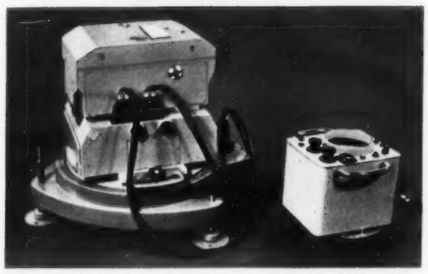
From the simple, but high-precision hand-held camera (**Linhof Aero-Technika** with Planar normal lens, Sonnar telephoto lens or Biogon wide-angle lens, for film packs containing 10 exposures, picture size 9 × 12 cm)...



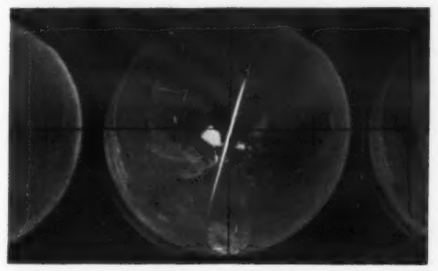
...via the remote-controlled camera installed in, say, the fuselage nose of a single-seat reconnaissance aircraft (**Vinten camera** with lens of 4 in. or 12 in. focal length for 500 roll-film frames, picture size $2^{3}/_{16}$ × 2¼ in.)...

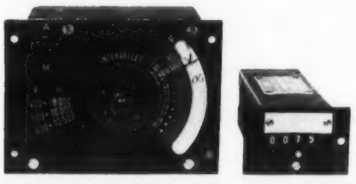
...to the fully automatic wide angle lens motion film camera for unmanned aircraft—runs the range of aerial cameras for small and medium picture sizes. The lower picture is from a section of a 170 ft 35 mm film, showing the interception of a target drone by a surface-to-air guided missile, photographed from the target itself. The two cameras (**Fairey WRETAR** f 11, focal length 0.633 in.—upper picture) are mounted back to back and have a viewing angle of 186° each; the lens (covered) is in the centre of the housing.





Aerial photogrammetry, on the other hand, requires serial cameras for large picture sizes (140 × 140 mm or 180 × 180 mm or 9 × 9 in.) with high-performance lenses and automatic overlap control (intervalometer). A single camera is sufficient for this purpose, as shown in the lower picture (**MRB 21/1818 aerial-mapping camera built by VEB Carl Zeiss, Jena,** with f 4 Pinatar lens of 210 mm focal length, picture 180 × 180 mm; separate control unit with sighting head to correct drift). For special purposes two synchronized cameras set at an angle of 30° to each other can be combined to form a so-called convergent camera (2 × **RMK 21/18 cameras by Zeiss Aerotopograph GmbH, Munich),** with Zeiss Topar f 4 lens, focal length 210 mm, picture size 180 × 180 mm; separate universal intervalometer with ground-glass view-finder).





The advanced **Type 31 reconnaissance camera** developed by **OMERA,** of Argenteuil, with interchangeable f 3.6 lens of 300 mm focal length, and magazine for 120 or 240 114 × 114 mm exposures, enables sharp vertical and oblique (lateral) pictures to be taken even from a fast, low-flying aircraft, at speeds of up to 625 m.p.h. and altitudes below 150 ft. The blur which would normally be induced by movement is compensated by a control unit (left) which, during exposure, moves the film at a speed equal to ground speed multiplied by focal length divided by distance of subject. Overlap is 60 percent, and shutter speeds are between 1/200 and 1/2,400 sec.

Another method is to carry two independent serial cameras with different lenses (installation of two fully automatic **Wild RC 7a plate cameras**—one with normal lens, one with wide angle lens—in the Swiss Federal Topographical Service photogrammetric aircraft).

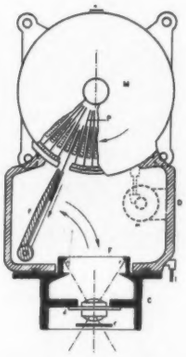
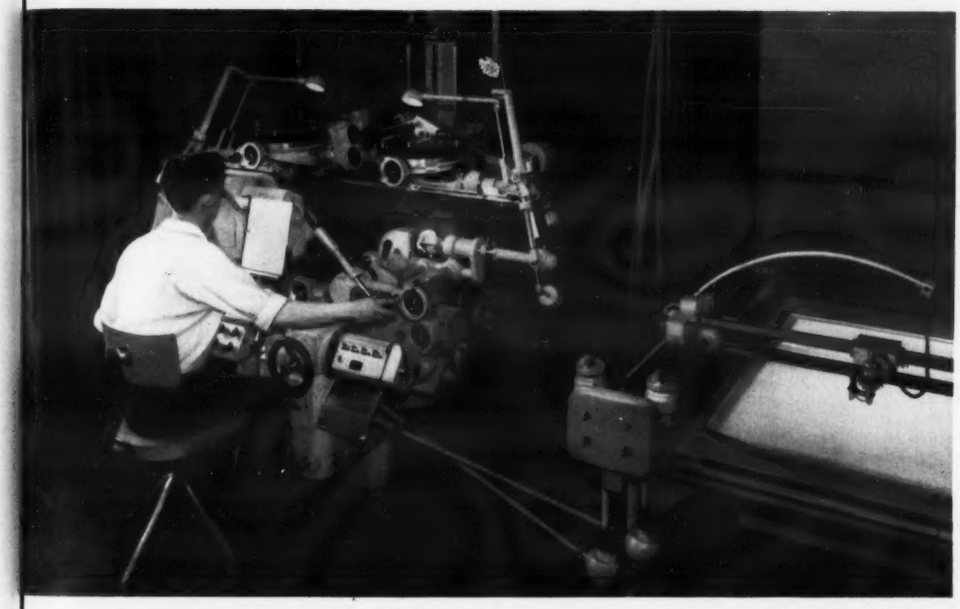


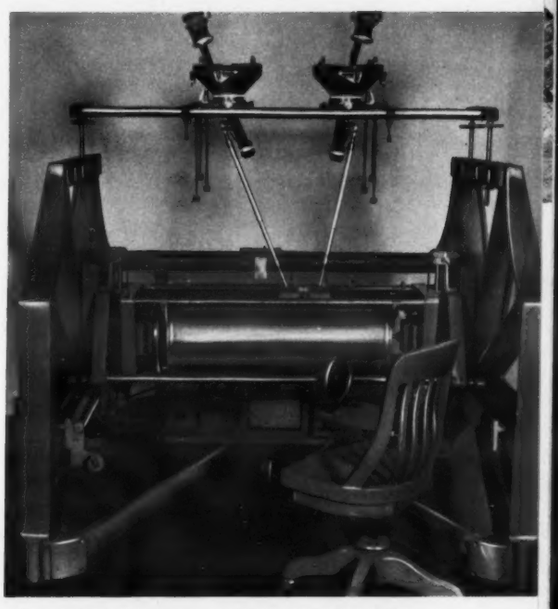
Diagram of the **Poivilliers automatic plate camera** built by **SOM** (Société d'Optique et de Mécanique de Haute Précision, Paris) for 96 plates measuring 190 x 190 mm. The plates are ejected from the (exchangeable) drum magazine, are pressed against the camera (outlined in heavy black) and re-inserted into the magazine. Electric motor; separate intervalometer; focal length 125 mm.

and Map-Making

Drawing point of the Wild A7 Autograph with electro-magnetic lifting device and a small 6-volt lamp (to right of drawing point) to illuminate the drawing sheet during plotting of a large-scale plan. The drawing point is synchronized with the floating measuring mark of the Autograph (which is kept continuously on the model of the terrain by stereoscopic observation) and controlled by two handwheels along the **x** and **y** axes.

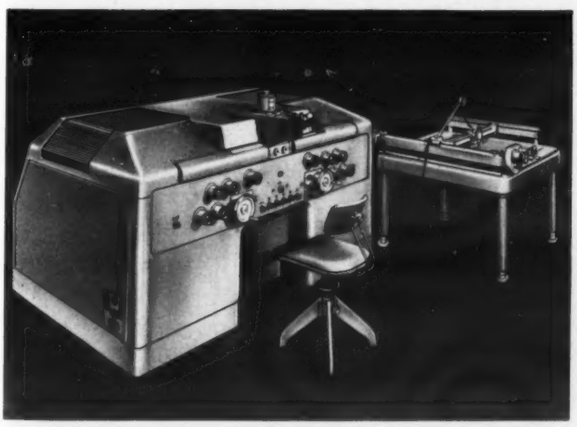


C. 8 Stereoplanigraph manufactured by Zeiss Aerotopograph, Munich, as used by Fairey Air Surveys Limited, London, for cartographic work. The two aerial pictures, which overlap by 60 percent, are set at the correct transverse and longitudinal angles (reconstruction of camera tilt) directly beneath the adjustable lamps; the operator looks at the stereoscopic model of the terrain through the eyepieces, controls the measuring mark along the **x** and **y** axes by means of two handwheels and places it on the model with the aid of a foot-disk or pedal (**z** axis). The electro-magnetic lifting of the drawing point is also controlled by a pedal. The equipment can be connected to an Ecomat electro-magnetic coordinate recorder.

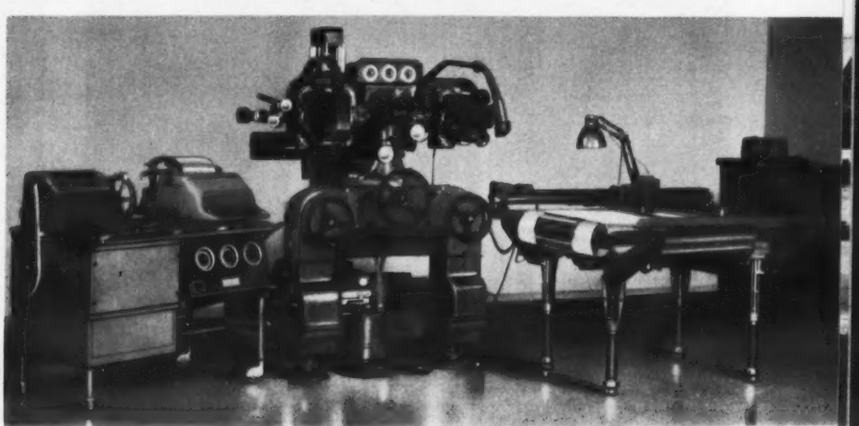


The Orthophotoscope of R. Bean (Geological Survey, Washington, D.C.) enables rectified plans of mountainous country to be prepared with accurate contour lines. Arrangements are said to be in hand for the manufacture of this equipment under licence in Switzerland.

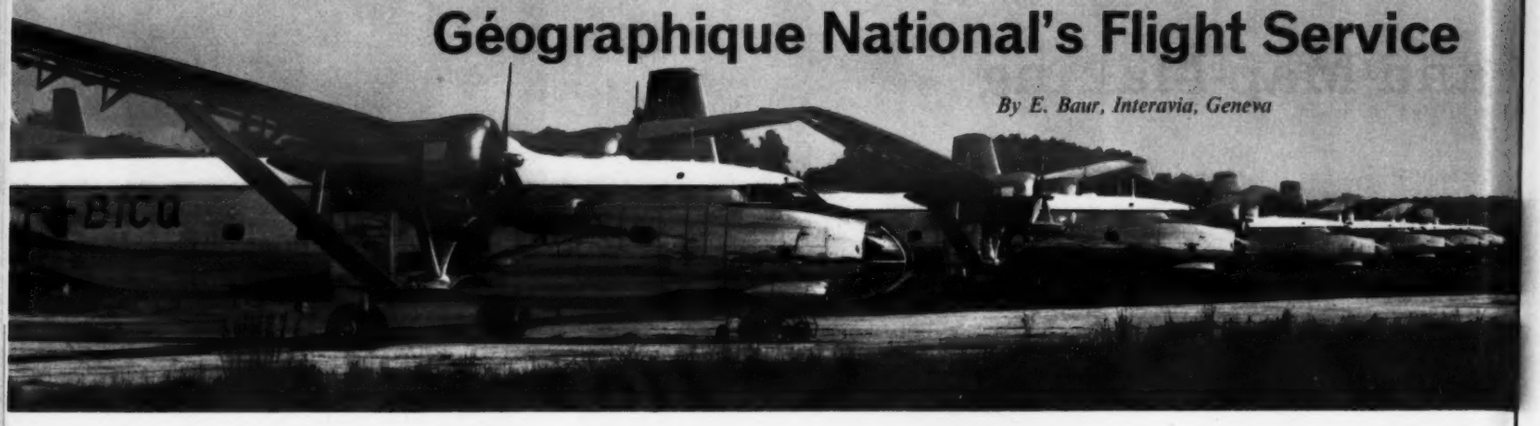
Stereometrograph built by VEB Carl Zeiss, Jena, a fully enclosed stereoscopic mapping equipment. The coordinates are transmitted electrically to the plotting table, and there are facilities for connecting the equipment to a Coordimeter (coordinate recorder) with typewriter and punched card machine.



Umberto Nistri's Model Beta 2 Photostereograph, a product of **Ottico Meccanica Italiana e Rilevamenti Aerofotogrammetrici SpA (OMI).** Fitted with a plotting table and coordinate recorder, the equipment is suitable for planimetric work and plotting contours. All three coordinates are controlled by handwheels.



Creil: Visit to the Institut Géographique National's Flight Service



By E. Baur, Interavia, Geneva

A narrow third-class road, a lonely red traffic light, and I have reached Creil airfield, about an hour's car drive northeast of Paris . . . Attention, aircraft landing! Creil houses a French Air Force fighter squadron and is also the home base of the *Institut Géographique National's Groupe des Escadrilles Photographiques*. The Air Force *Mystère IVs*, which had so to speak acted as sky signposts, have meanwhile landed, and I drive round the base to the geographical photographers' offices, hangars and workshops. Director Rumeau of the IGN certainly did not exaggerate when he told me his Institute owns an impressive aircraft fleet of unsurpassed efficiency. In fact, the photographic units operate no fewer than twelve Boeing B-17 four-engine bombers converted for aerial survey work, and have recently received eight Hurel-Dubois HD. 34 survey aircraft as well.

The historical background

The Institut Géographique National was re-established in 1945, as successor to the Army's pre-war Service Géographique, but now under the Ministry of Public Works and Transport. Three years later the Section de Photographie Aérienne was expanded to form the Groupe des Escadrilles Photographiques. Today the Groupe employs some 150 to 200 specialist staff on preparing the tens of thousands of aerial photographs of France and the French overseas territories which the IGN requires each year. In view of the fact that survey flying is so greatly dependent on weather conditions, this task demands an extremely high degree of devotion to duty and automatically leads to the strict working discipline which every visitor senses as soon as he entres the Creil base.

Director P. Gleize and his assistant Carnec make no secret of the fact that they make very high demands on their staff and insist on the closest kind of teamwork.

The question of suitable aircraft

What were the reasons which led to the choice of a two-type fleet consisting of B-17s and HD. 34s? The twelve B-17s forming the basic equipment were bought some years ago under relatively favourable conditions from USAF surplus stocks, and the HD. 34 is the ideal aircraft of French design. The B-17s are used primarily for photographing from medium and high altitudes (scales of 1/20,000 and above), while the HD. 34s—with their lower speed—work at low to medium altitudes (scales below 1/20,000). Both types use a crew of five: pilot, engineer, navigator, radio operator and photographer. The question of the ideal survey aircraft will probably never be solved, since requirements vary too considerably from one mission to another. In certain cases—for example, for photographing African desert areas—a very fast, high-flying aircraft, such as the RB-47, which could cover a relatively large area within a short time, would fill the bill. But any plans of this sort come up against the tremendously high operating costs for aircraft of this category. Basically, the aerial survey service will always be obliged to find compromise solutions, and the IGN's air units appear to be well satisfied with their choice.

Photographic equipment for the Hurel-Dubois HD.34 used by the Institut Géographique National's Groupe des Escadrilles Photographiques. A small winch is used to hoist the 150-lb film magazine onto the camera. Half hidden by the photographer is one of the widely used SOM-Poivilliers cameras (focal length 125 mm; other cameras with focal lengths of 210 mm and 300 mm are also available).

All data have been passed to the photographer, who has made the necessary settings on his control unit . . . all that remains for him to do is to push a button, and the apparatus will work fully automatically.

In addition to twelve Army surplus B-12s, the Institut Géographique National uses eight twin-engine HD.34s built by Société de Construction des Avions Hurel-Dubois. These are powered by 1,525 h.p. Wright 982-C9-HE engines and operate—depending on mission—at all-up weights of between 38,200 lb and 42,400 lb, carrying up to 5,720 lb of photographic equipment. The HD.34 is a derivation of the HD.32 commercial and transport aircraft, the modifications having been introduced mainly at the recommendation of the IGN. The aircraft is suitable for the following typical missions: Mission I: Flight to area of operations 325 miles; seven hours' photographic flying at 10,000 ft at a cruising speed of 125 m.p.h.; return flight 325 miles; photographic equipment carried 5,720 lb. Mission II: Outward flight 500 miles; eight hours' photographic flying at 16,500 ft and 175 m.p.h.; return flight 500 miles; photographic equipment as above. Mission III: Outward flight 500 miles; eight hours' photographic flying at 23,100 ft and 155 m.p.h.; return flight 500 miles; photographic equipment 1,870 lb.

Aboard an HD.34

How does the practical side look? . . . So as to give me a realistic picture of his work, Director Gleize kindly organized a crew for me. An HD. 34 was prepared for take-off, and the Director climbed into the cockpit... Take-off on a simulated survey flight. Unfortunately, the weather was not as good as it might have been. We set off close below a broken cloud cover, and the good old Hurel "staggered" a bit as it flew over the industrial areas of Creil at an altitude of barely 3,000 ft and a speed of 135 knots. I took my place on a folding chair next to the navigator up in the glass nose, where I had no difficulty in following the precision work of the well-matched team. A deviation of no more than 60 to 70 ft from the planned course is enough to plunge the navigator into the depths of despair. In perfect weather conditions, of course, no such deviation would occur. Meanwhile the photographer has fed the required data into his control unit and now pushes the button which starts the camera off on its automatic operation. The selected overlap for successive frames is 60 percent in the direction of flight, and 10 percent laterally.

The HD. 34 can, if required, carry two SOM-Poivilliers cameras (manufactured by Société d'Optique et de Mécanique de Haute Précision) and some dozen and a half SOM magazines of 96 plates (19 × 19 cm). In addition the aircraft has been designed in such a way that other types of camera can be installed without major modifications, such as American Fairchild, Italian Santoni (Officine Galileo), Swiss Wild cameras, etc.

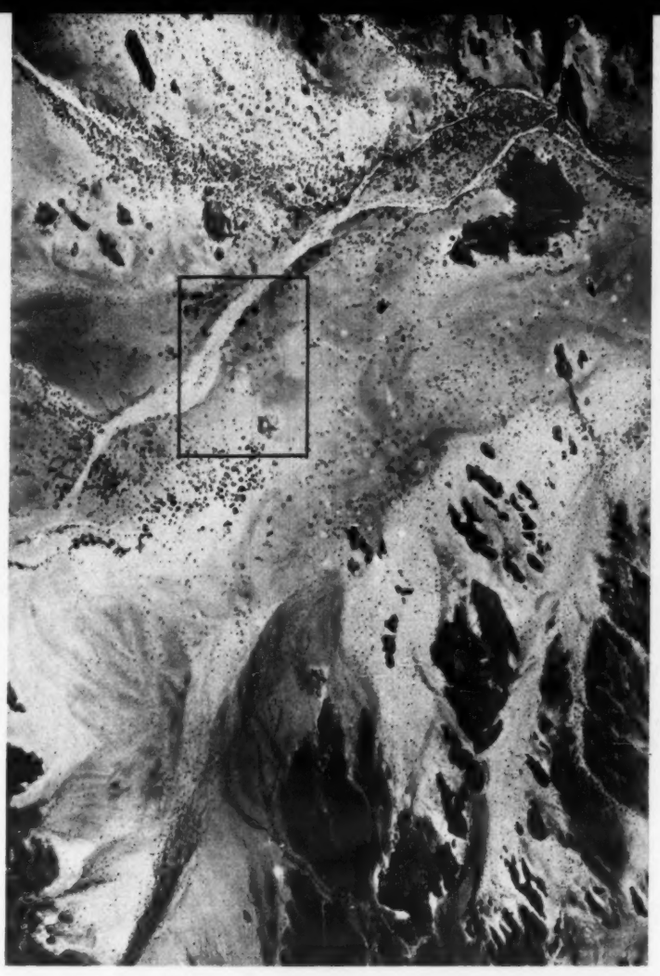
Having arrived at the end of the run to be photographed, we made a 180° turn and flew back to Creil. Coming in to land, Director Gleize had to thread his way between a number of *Mystères* to get down to the runway.

Our simulated operation had lasted roughly one hour. Normally, however, the Creil crews are used to better things. Members of the four squadrons told me, for instance, that a successful working day must bring in something like 600 to 800 photographs on a scale of, say, 1/50,000. This means ten to twelve hours' flying and a consumption of ten of the 150-lb, 96-frame magazines. The magazines must be set up on the cameras during flight. But this is not the end of the day's work. After landing come several hours' intensive work in the laboratory, and aircraft and equipment must also be prepared for the next day's operations. Finally, the developed plates must be sent to the IGN's Service de la Photogrammétrie at Saint-Mandé, where the actual cartographic interpretation can now begin.

The maintenance service

Nor can the ground mechanics complain of shortage of work. The Groupe's twenty multi-engine aircraft must be serviced, overhauled and kept in repair. So as to be independent of outside help and to cut down unserviceability rates, the Groupe formed its own Section Technique Avion, which is responsible for maintenance, upkeep and general inspection of the survey aircraft. Small, but well-equipped workshops and an independent engine test bench are available for this work. A modest staff of technicians and mechanics—for the twelve B-17s alone the Groupe has total of 140 spare engines!—is permanently attached to the Section, though there are times when they must be reinforced by members of the four flying squadrons. This has the welcome "side effect" of familiarizing the flying personnel with the equipment they use "in the field". This applies not only to the aircraft, but also to the photographic equipment.

Written in invisible letters on the doorplate at Creil is the word "precision" . . . This motto applies not only to the actual flying and photographic work, but also to the maintenance of the sensitive technical equipment. Scarcely have the engines stopped turning on the return from perhaps several weeks' work on an overseas mission, than the aircraft is surrounded by a swarm of highly-qualified mechanics. Night work is by no means exceptional, for the next day may well bring a deep blue, cloudless sky . . . in other words the right flying weather for the Groupe. ⟶



In 1949 the IGN started out on a systematic aerial survey of the French overseas territories. Pictures show a 1/50,000 photograph and a six-fold enlargement of the section outlined. The Groupe des Escadrilles Photographiques also works for foreign countries. Its personnel and technical equipment are used under contract to the United States, Britain and many countries in the Near and Middle East. Groupe aircraft operate today in all continents.

Photographic Reconnaissance

Strategic Air Command's Boeing RB-47E six-jet long-range reconnaissance aircraft (foreground), escorted by a bomber of the same type.

By General L. M. Chassin, Paris

The collection of information on the enemy's dispositions and plans has been one of the military leaders' major preoccupations since the earliest times. As a mediaeval French dictum had it, "if the hosts knew what the hosts were doing, the hosts would beat the hosts." Since time immemorial, every possible means—from cavalry to spies—has been mobilized in order to "tear the veil" as Napoleon put it, or "pierce the fog" in the words of Clausewitz.

Scientific discoveries have always been applied to warfare, and since its earliest days photography has been no exception to this rule. Admittedly Nadar, the first pioneer of aerial photography, who was a convinced pacifist, in 1859 rejected the French War Minister's proposal that he should put his talent to the service of the Army; but he was destined to remain an exception. By 1862, during the seige of Richmond in the American Civil War—the war which brought so many military innovations, such as the ironclad, submarine, mine, torpedo, etc.—Union General MacClellan had two excellent oblique photographs taken by the balloon which was telegraphing him information on the enemy. These photographs revealed to him the Confederates' defence positions. Wilbur Wright and a Frenchman named Meurisse took photographs from an aeroplane in 1909, and Captains Fequandt and Marconnet made the first military photographic reconnaissance, along the Mourmelon-Vincennes route, in 1912.

Other armies followed suit, and it is interesting to note that in 1914 the Russians were in the lead in airborne photographic equipment, as also in radio.

The first World War brought enormous progress in photographic reconnaissance, particularly after the front lines had become static and when the time factor between the actual taking of the photograph and its utilization was less important than during a war of movement. The first cameras for vertical photographs appeared in 1915, and original solutions were found for the technical problems, such as that of vibration, which was overcome in France by a tennis ball suspension system. During the battles of Verdun and the Somme in 1916 pictures taken by photographic squadrons, heavily escorted by fighters, were already being interpreted by experts and frequently enabled staffs to make important discoveries concerning the enemy's designs. However, the aircraft's inability to penetrate far into enemy territory confined aerial reconnaissance to a narrow, congested battlefield. The machines used were conventional reconnaissance two or three-seaters, with the pilot manning the forward defences, and the observer in a turret covering the rear. A place was found beneath the operator's feet for the camera and its numerous hand-operated magazines, and photographs were taken through a hole cut in the floor. To take an oblique picture the operator had to stand up in the cockpit, exposed to the four winds!

Nevertheless, great progress had been made by the end of 1918, in both equipment and operation, and between the two wars reconnaissance units long formed a major portion of the air forces of all countries.

In 1925, during the revolt of Abdel-Krim in the Rif, French Navy Goliath F-60 bombers were used to prepare the first existing maps of Spanish Morocco. Within a few months—a considerable exploit for those days—they enabled the Army's Service Géographique to prepare, with the aid of rudimentary plotting equipment, a complete map of the area, showing not only physical characteristics but also ethnic distribution—the crews had carried along natives of Morocco who were familiar with the country and provided the names of the tribes, villages, mountains and wadis flown over. At the same period the Royal Air Force was using the "air control" system in Iraq, and aerial cartography was developing in all countries. The first automatic, film cameras appeared. At the same time mobile developing equipment came onto the scene, eliminating the baths of developer and fixative, the endless washing of films and the drying of prints fixed to wires by clothes pegs outside the "photo section" hut. Unfortunately, as technical improvements were made, the science of interpretation was gradually lost.

The only truly military missions were carried out for the intelligence services by light civil aircraft taking part in international rallies. The pilots were officers in mufti and "poor navigators" who

The Lockheed U-2 single-seat "high-altitude research aircraft" (Pratt & Whitney J75 jet) has a ceiling of up to 82,000 ft, high speed and very long range (4,000 st. miles). The Russians claim to have shot down an aircraft of this type, equipped with automatic film cameras and electro-magnetic measuring instruments, over Sverdlovsk (Urals) on May 1st, 1960. It is assumed that the aircraft was forced down to a low altitude after flame-out of its jet engines.

lost their way and wandered by chance over airfields or factories, where they took oblique photos with advanced pocket cameras. The British even managed to send a large American twin-engine aircraft, the Lockheed 12A, to these rallies. The "owner," Australian-born Sidney Cotton, was able to take some magnificent photographs of stores and fortifications in the Rhine valley... while giving a joy ride to a jumber of Luftwaffe colonels and generals who had expressed a desire to fly in the "kolossal Lockheed." The aircraft was equipped with three carefully hidden automatic cameras (one vertical and two oblique).

Although nothing definite is known, it is highly probable that the Germans did the same over Allied countries.

World War II brought a revolution in photographic reconnaissance. Ever since 1915 it had remained virtually on the tactical level. It was now to venture into the strategic domain.

The task was no longer to detect troops moving on foot in the vicinity of the battlefield. Mechanized divisions moved so fast that, however short the time required for development and interpretation, pictures arrived too late. On the other hand, since the air force had moved up into the place of main service, following the Douhet theory, a more rewarding field was opened to aerial reconnaissance. Once aircraft were capable of striking at the heart of the enemy's industrial and military power, it was essential to know what and where to strike. Next it was essential to follow the progress of destruction and the repairs carried out by the enemy. And finally, it was essential to keep a close watch on the whole of the enemy's territory in order to divine his intentions, follow his manufacturing progress, the appearance of new weapons—submarines, tanks or secret aircraft—and assess his efforts to escape bombing damage by dispersal, camouflage or the installation of vital centres deep in underground caves.

All this required special long-range photographic aircraft capable of avoiding the defences, new flying techniques, new cameras capable of operating automatically at high altitude under very difficult weather conditions, and finally a vast interpretation service using the help of specialists from a wide variety of fields.

Once again it was Sidney Cotton who initiated the first revolution when he decided to abandon, for long-range photographic work, the conventional reconnaissance aircraft with its three-man crew, machine guns and necessarily reduced performance, in favour of a pure fighter, namely a *Spitfire*, whose armament was replaced by photographic equipment. The aircraft's sole defence thus lay in its speed and ceiling, which were to enable it to escape the enemy's fighters. This daring proposal was accepted by the RAF and led to innumerable exploits during the war: the watch on the threatened invasion in 1940, the discovery of the "Bismarck" in 1941, the "Tirpitz" in 1942, new German submarines, the V2 tests at Peenemünde, the V1 launching sites in France and Holland in 1943, underground factories in 1944, the first German radar station at Bruneval and the first Me163 and Me262 rocket or jet aircraft. The blame for humiliating setbacks, such as the escape of the "Scharnhorst" and "Gneisenau" from Brest or von Rundstedt's surprise offensive in January 1945, cannot be imputed to the photographers; they merely prove that there is no man so blind as he who will not see and that behind even the most accurate information are the human mind and imagination.

In addition to the photographic *Spitfire*, the British also successfully used the *Mosquito*, and the Americans the P.38 *Lightning*, the aircraft in which Antoine de Saint-Exupéry made his last sorties over southern France. However, photographic reconnaissance from very high altitudes suffered from serious handicaps, despite the progress made in cameras (increase in the viewing angle and in power of resolution, reduction in distortion). But often, the small scale of the pictures made it impossible to distinguish details of capital importance. Hence photographic aircraft were called upon to carry out very difficult and dangerous missions, known as "dicing," at very low altitude, taking oblique photographs from 150 ft of points which were generally heavily defended. This required extremely accurate navigation and an unusual disregard for danger. By the end of the war, however, the German jet fighters were too fast for the Allied photographic aircraft. The *Lightnings* had to be escorted. Just the same, the Messerschmitt jets arrived too late, and the Luftwaffe was crushed under the weight of numbers. Many of the aircraft of the Allied tactical air forces, and all the Allied bombers were equipped with cameras, and photography both by night and by day became a routine matter. Germany was watched minute by minute, twenty four hours a day. Strangely enough Germany, who had always been in the lead in technical progress in the optical field, never managed to make proper use of photographic reconnaissance. The Luftwaffe's methods of interpretation were of the most rudimentary kind. Yet before being dismissed by Hitler, General Fritsch had made this prophetic pronouncement: "The side which has the better photographic reconnaissance will win the war."

If the hosts had known what the hosts were doing...

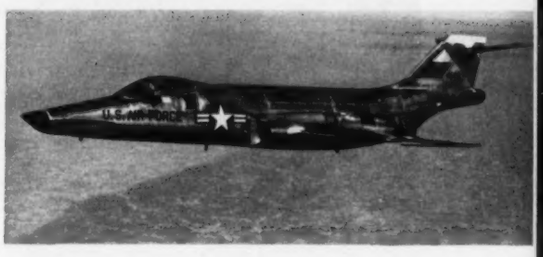
*

Since the end of the war, the situation has not advanced greatly. Despite the advent of revolutionary weapons, the Services' needs as regards information have remained unchanged, and photographic reconnaissance has lost none of its importance.

The Army itself continues to be interested primarily in the tactical domain. But the battlefield of the future may be an atomic one, when it will stretch to cover hundreds of miles. The speed at which troops move has increased still further, and photographic techniques have become too slow. Only television and a form of radio communications which cannot be monitored by the enemy will be able to give military leaders an immediate and living picture of the situation. Nevertheless, there will still be many things on the battlefield which do not move: stores, repair shops, fortifications, airfields—however small and hastily prepared the latter may become.

Tomorrow perhaps there will be pilotless reconnaissance missiles, but their job will be the same one.

In subversive war, where the skies are clear of the enemy, photographic reconnaissance can render greater services than is commonly believed. It can, for example, reveal the enemy's "fixed points" (depots, hide-outs, command posts, training camps, etc.) through the careful observation of such minute signs as footprints or cattle tracks, forest paths, loads abandoned along roads. Both in Indo-China and in Korea the reconnaissance squadrons did yeoman service.

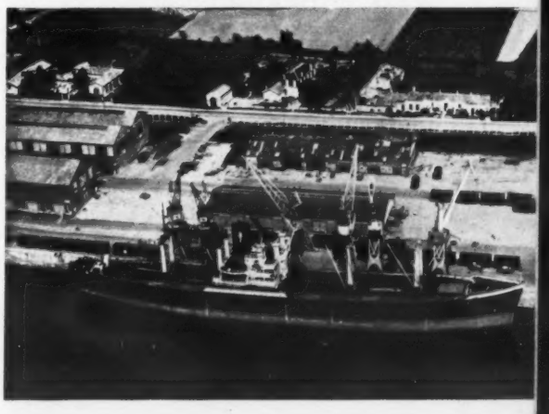


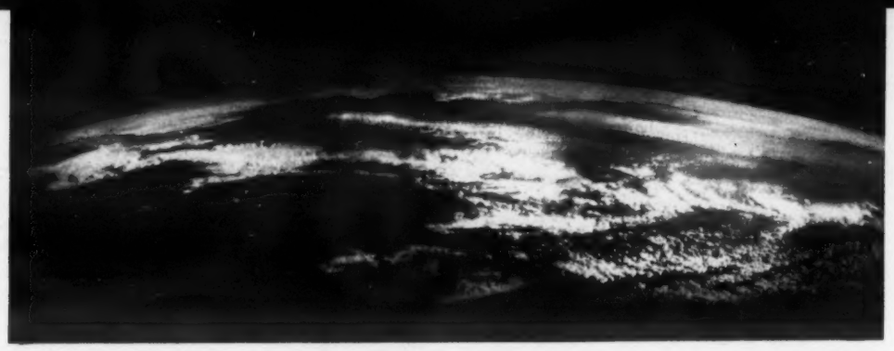
Aerial photograph of the River Gila, Arizona, and the Sierra Estrellita, taken at supersonic speed by the USAF's Air Research and Development Command. The aircraft was a McDonnell RF-101 *Voodoo* (upper picture).

The Navy's needs remain very much what they were in the past. It too has "fixed points" in the shape of ports. Even if beachhead landings become commonplace, the time factor will not preclude the use of photography. A fleet at sea, a convoy, even an isolated pirate will be good reconnaissance targets. Finally, the work going on at naval dockyards must always be carefully watched.

As for the Air Force, it will continue to have its own needs and to be responsible for meeting some of the needs of the other Services and all those of the supreme command. In some Western circles there is today a certain tendency to think that reconnaissance will be unnecessary in atomic warfare, since the only targets that can be attacked will be those which have been accurately located and selected in advance. Once an atomic war starts, they argue, it will be too late to go

Oblique photograph of the harbour installations at Bordeaux, taken by a French Air Force Republic RF-84 in high-speed, low-level flight (400 knots at 300 ft). Camera used was a speed-compensated OMERA 31 of 200 mm focal length; f = 1 : 4, exposure 1/1,600 sec.





This picture of the overall weather situation over the western Atlantic is built up of five separate photographs taken by a *Nike-Cajun* rocket. The region photographed extends over roughly 1,000 miles, from the southern border of the State of Maine to central Florida.

The U.S. Army's Radioplane (Northrop Corporation) SD-1 pilotless reconnaissance drone is launched on a remote-controlled observation flight. Above the target area the film camera or television camera is set in operation by a radio command; further radio orders then direct the drone back over home territory, where it lands by parachute.

out and look for targets, as was the principal mission of reconnaissance in the old days.

Perhaps! But it will always be necessary to follow the results obtained by our counter-offensive. Moreover, a future war may quite well be not atomic, but conventional. In any case, NATO continues to attach considerable importance to photographic reconnaissance, on both the tactical and the strategic level.

Today, as in 1939–45, the aircraft which equip the photographic reconnaissance units are fighters with all or some of their armament removed. In the United States examples are Tactical Air Command's twin-jet RF-101A *Voodoo*, the Chance Vought F8U-1P *Crusader* specially equipped for cartography with fuselage underside flattened to take three Cax-12 trimetrogon cameras and two K17 vertical cameras, the Douglas A3D-2P *Skywarrior* which carries a crew of three, twelve cameras and its tail armament; in Britain the *Hunter FR Mark 10* with cameras in the fuselage nose, and the long-nosed Supermarine *Swift FR Mark 5* with three cameras in the place of two Aden cannon; in Italy the G.91R with three Vinten cameras for forward and lateral oblique photographs; in NATO the elderly RF-84, and in the USSR the Yak-25 *Flashlight B* with stretched nose and undisclosed equipment.

Today's bombers nearly always have a reconnaissance version. It suffices to list the United States' Douglas RB-66, Boeing RB-47K, Martin RB-57D and Convair RB-58A *Hustler*, Britain's V-bombers and Russia's IL-140 to prove that photographic reconnaissance is far from dead. The RB-47K, for example, which has a crew of three, is equipped with seven cameras: one with vertical axis, two with axes slightly laterally inclined, three with sharply inclined axes and one aimed obliquely forward. Flying at 40,000 ft, the aircraft can photograph one million square miles in three hours. Cartography has, in fact, become a military mission in an age where missiles cannot count on the human eye to detect their targets and when an error in coordinates can become fatal over intercontinental ranges. The United States has equipped the Lockheed C-130A *Hercules* with twelve cameras. In Britain the Royal Air Force has become the country's biggest aerial photography enterprise. It uses *Canberras* for high and low level photography, *Valiants* for photographic and radar reconnaissance and *Victors* solely for radar cover.

Paradoxically, the "dicing" method has perhaps become the least dangerous, since flight at very low altitudes offers a means—at any rate at present—of evading detection by the enemy's radar. But it requires a special technique to avoid the streaking of photographs due to the movement of the film during exposure, however short the latter may be. This technique takes the form of synchronization, where the film advances at a speed corresponding to the angular displacement of the terrain, and the shutter remains permanently open. Using this principle, the French firm of OMERA has developed a camera of reduced dimensions which can take vertical or oblique pictures from altitudes below 150 ft and at speeds of above 600 m. p. h. with an impressive clarity of detail.

All the technical progress achieved in photography is immediately utilized by the military. Colour photography, for instance, gives very useful contrast, and infrared photography, in which the properties of chlorophyll produce characteristic colours on the film, makes it possible to distinguish between dead and living vegetation. In this way even the most artistic camouflage using branches or leaves can easily be detected.

The earth is shrinking, and space is opening up before us. Already satellites such as *Tiros*, to photograph the whole of the earth's surface, are planned. Admittedly, their cameras still have a low power of resolution, but the time is not far distant when regions that are today but little known, such as the Arctic and the Antarctic, will be mapped easily and clearly.

In the meantime, mutual aerial inspection as proposed by President Eisenhower at Geneva in 1955 may become a reality if men of good will gain the upper hand in all countries. The results which can be obtained by aerial photography today are such that few major military installations could escape the magic eye of modern cameras.

Already the use of radar enables a photographic bomber to cover the whole of the Mediterranean on a single sortie, regardless of atmospheric conditions. Although still rudimentary, the radar picture is adequate for identifying certain targets. There can be no doubt that improvements will be rapid.

This brings us to the paramount weakness of photographic reconnaissance aircraft: their inability to produce good results in bad weather or even at night. Here the scientists should redouble their efforts. Until the aircraft can "see" 24 hours out of 24 and 365 days a year, it will not really be the supreme weapon it is claimed to be. Radar and infrared photography can perhaps provide the solution. Now, as of old, "the hosts must know what the hosts are doing." ◆◆

Roughly one third of the aircraft in the Fiat G.91 strike units will be equipped for tactical reconnaissance missions (G.91R version). Three Vinten cameras are fitted in the nose (left-hand picture) above special optical glass windows. The G.91R has the same take-off, flight and landing performance as the standard model (Bristol Siddeley *Orpheus* jet) and is armed with four 0.5-inch machine guns.

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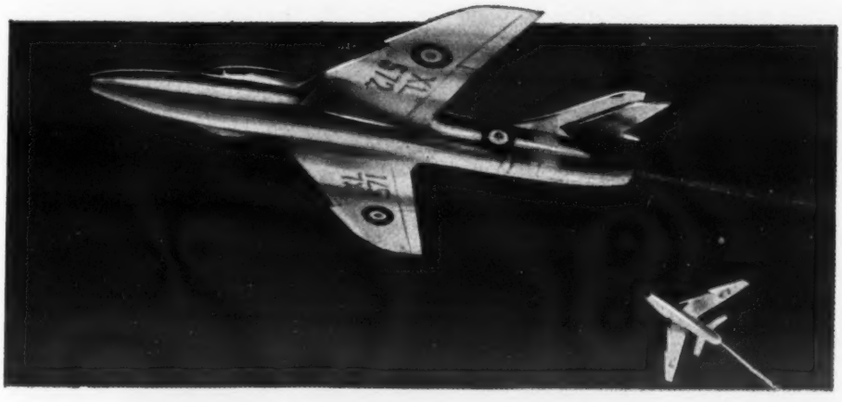

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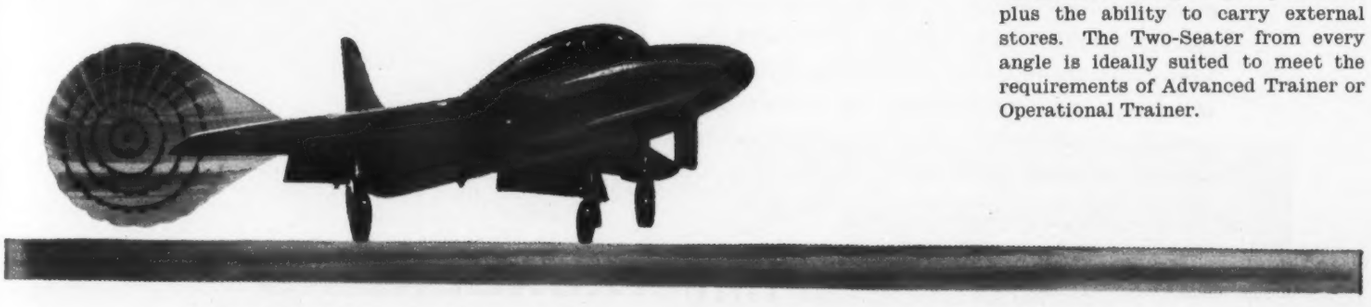

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AS FOR THE CHAMELEON,
DEMANDS VERSATILITY

You cannot take a chameleon by surprise. It can always adapt itself to the prevailing conditions. It owes its survival to this adaptability. The same principle applies in modern warfare. A defence system which is flexible in application is less likely to be defeated than one which is not.

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Evolution is going on. Already the successor to Thunderbird has been under development for some considerable time. Employing advanced techniques and retaining its full mobility it will have, among other things, increased low level capability and increased range.

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on transmitters

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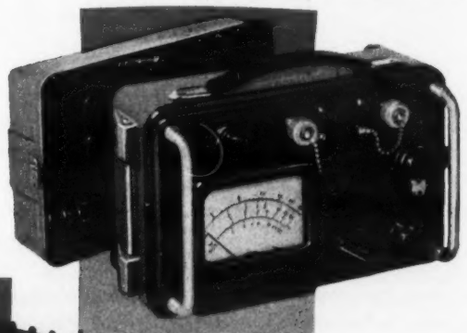


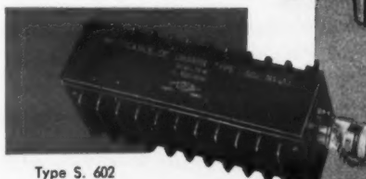
VSWR METER TYPE TO 201 A

Incorporates VHF/UHF oscillator.
Frequency range : 65-500 mc/s, on a single direct reading scale.
Nominal reference impedance : 50 ohm.
Direct reading reflection coefficient
3 VSWR scales : 1-∞ , 1-2, 1-1.3
ρ : 0-1 (± 5%).
(single dial).
Power supply : A. C. 40-400 c/s.

R. W. METER TYPE NTO 101

Permits rapid adjustment of transmitter/waveguide/aerial assembly.
WSWR regulation.
VHF and UHF power measurements.
Self-contained power supply:

LOAD RESISTOR



Type S. 602

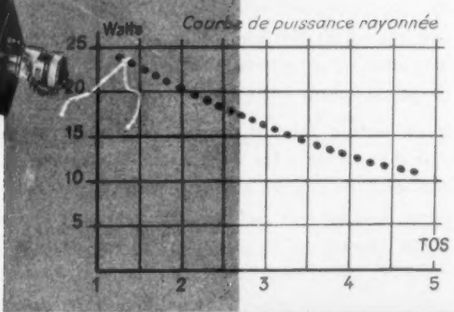
1 - Power measurements.

Frequency range : 75-500 Mc/s.
2 scales : 0-7 watts
direct reading.
0-25 watts
Nominal resistance : 50 ohm.
Load resistor : type S 601 (5 watts)
type S 602 (25 watts).

2 - VSWR measurements.

Frequency range : 75-100 Mc/s.
Nominal impedance : 50 ohm.
VSWR scale : 1-∞.

Direct reading from 3 watts upwards.
Modulation control : by built-in jack.



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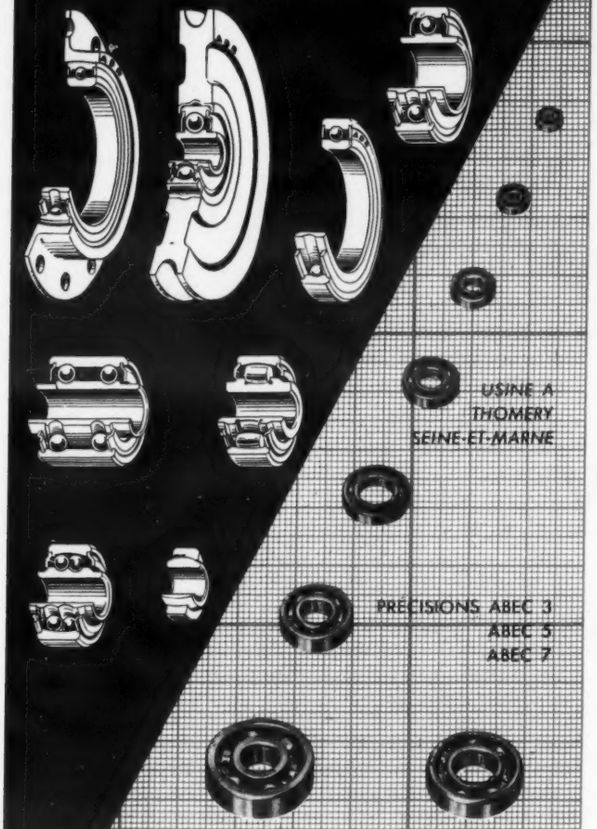

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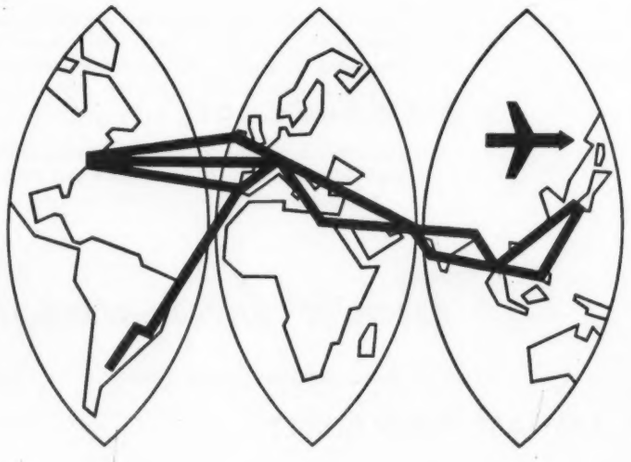

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Bush Flying in Canada

H. M. Willmot, Don Mills, Ontario

Larger aircraft have supplemented the small bush planes. The frontiers have been pushed farther north. The pilot no longer flies "by the seat of his pants." But essentially, the character of bush flying remains unchanged, and its vital contribution to the development of Canada's North undiminished. Even further south bush flying continues to fill a vital need. There are still many isolated settlements which depend on aircraft for mail and supplies, and other essential services include fire fighting, social welfare work, wild life conservation, survey work, pest control, fur trading and the opening up of new areas for mining and exploration. Finally, a fairly recent, but rapidly growing field for bush operations is that of tourism, since fishing and hunting deep in the wilds of Canada have become popular with both Americans and Canadians.

Bush flying was born in Canada immediately after World War I, when a host of returning pilots sought a career in aviation. Apart from difficulties arising from the climate, northern Canada is an ideal aviation country. Distances are enormous; there was and still is a great scarcity of surface transportation; for approximately two thirds of the year the seaways and inland waterways are frozen; and the terrain of rock, water and muskeg in summer, and pressure-ridged ice in the winter, makes surface travel slow and arduous.

To these pioneer fliers goes much of the credit for opening up the wealth of natural resources hidden in the North, whose development accounts for the country's phenomenal growth during the past two decades. And it was on Canada's northern air routes that air freight was born. Subsequently it grew at such a pace that for many years Canada led the world in the volume of air cargo carried.

Nearly every province had its bush operators during the '20s, but the centre of the assault on the North was Edmonton, Alberta—the only city of major size in Canada which is more than 200 miles from the United States border. Western Canada Airways, the first sizeable air carrier in Canada, came into being here, and in 1927 became the first commercial airline to operate a service over the barrens between Winnipeg and Fort Churchill. It was also a Western pilot, C. H. "Punch" Dickins (now Sales Director at de Havilland Canada), who in 1928 set down his pontoon-equipped Fokker at Aklavic, only 60 miles from the Arctic Ocean.

Despite many pioneer achievements and historic flights, bush flying did not really come of age until after World War II. Two factors contributed to its sudden growth. One was the realization by the United States that it was rapidly becoming a "have-not" nation in natural resources and its resulting willingness to pour money into the development of Canada's hidden wealth. And the second big boost came from the construction of the Distant Early Warning Line and the Mid-Canada Line. Nearly all of Canada's bush air carriers participated in the airlift of supplies for this work.

The biggest change which has taken place in bush flying operations came about at this time, with the introduction of multi-engine wheeled aircraft. The northern air carriers, most of whom were greatly strengthened by large contracts during the building of the radar lines, were left afterwards with a surplus of aircraft they had used for heavy hauling. Many of these have now been put to work on all the larger bush operations in the North, landing either on an ice strip or a prepared landing strip. For example, PBY-5 *Catalinas* are playing an important part for both Canadian survey companies and carriers taking supplies to isolated areas.

All construction and mining equipment for Canada's North must be flown in by air. During the construction of the DEW Line, World-Wide Airways flew up to 1,500 hours per month, using DC-3s and C-46s.

Typical prospector and his load waiting to be flown into northern Quebec by a *Beaver*, first of de Havilland Canada's line of "flying truck" STOL aircraft designed to meet Canadian bush flying conditions.

Last summer, Bradley Air Services' Piper *Super Cubs* with special balloon tires and navigation gear, logged 3,000 landings on glaciers, shale peaks, tundra and mud flats.

Logging operations in British Columbia. Picture shows a Cessna 180 as used by West Coast Air Services Ltd., Vancouver.

At the other end of the scale, Welland W. Phipps has been making history in the Canadian Arctic with Piper *Super Cubs*. Phipps, who is Vice-President of Bradley Air Services Ltd., Ottawa, has proved that a light aircraft, specially modified for the purpose, can perform the same service in geological and other exploration work in the high Arctic as the more complex and costly helicopter.

The first bush fliers mostly used imported landplanes converted for their needs by fitting seaplane floats and water skis. Performance, however, left much to be desired. Then about 1929, a few pioneer organizations turned their hand to the design of aircraft specially suited to Canadian requirements. Among these were the Fairchild 71 and 82, the Vickers *Vedette*, the Fleet *Canuck* and the Noorduyn *Norseman*. The latter, one of the best-known Canadian bush aircraft, was first delivered in 1936 and has only recently been phased out of production. There are believed to be over 500 still in service.

The *Beaver*, first of de Havilland Canada's "flying trucks," was produced in 1947 and was followed a few years later by the *Otter*, which is really just a king-sized *Beaver*. The *Otter* can be said to have started the trend towards the use of heavier aircraft in bush flying. Its payload—1½ tons—was almost double that of any other bush plane then in operation, and it was available as a land, sea or ski machine built to endure sub-zero temperatures. It is said to have altered mining practices by reducing transportation costs by 30 to 40 percent. Today bush camps are completely modernized, and some manufacturers are even prefabricating complete buildings to fit into the aircraft which will be carrying them to the mining properties.

Typical of the larger aircraft used by Canada's northern carriers is this Bristol *Freighter*, which Wardair operates out of Yellowknife, Northern Territories.

Although continuing improvements in aircraft and equipment have taken much of the glamour and the romance out of bush flying, it is still far from being a push-button operation or one to be undertaken by the faint-hearted. Bush pilots of today, especially those operating in the Arctic, still need much the same qualities as their forebears. They must be resourceful, self-reliant, have the know-how to maintain their aircraft and equipment and possess the pioneering spirit. If it is winter the temperature may be as low as −50°F, and the best the pilot can expect is an average of −15 degrees. In spring, summer and autumn, winds may be up to 70 knots. At any time of the year the landscape down below looks monotonously white and empty, hour after hour and some times day after day. Small wonder that the pilots who tackle this kind of flying must be a special breed.

Today there are six major air carriers and around 100 smaller ones serving Canada's North with some 800 aircraft. No less than nine went out of business during the first two months of 1960, but almost as many new operators started up. This is probably the result of the so-called "open" policy of Transport Minister George Hees liberalizing conditions under which licences are granted to operators. Most of the non-scheduled carriers are bitterly opposed to this new policy and feel that it will end with a lowering of safety standards in an effort to meet the stiffer competition.

From the beginning, both Federal and Provincial governments have recognized the importance of bush flying to Canada and made extensive use of it. Today, for instance, the Saskatchewan Government has not only a well-established airline to provide transportation into its northland, but also a justly famous air ambulance service. On the Federal level, the Royal Canadian Mounted Police makes use of its Air Services to ferry prisoners and mental patients from isolated areas, transport men and equipment to outposts, bring police and dogs to search areas in order to trace missing or wanted persons, stolen livestock, missing vessels and many other things.

Keeping a fatherly eye on all bush operations from coast to coast is the Royal Canadian Air Force's Search and Rescue service, which undertakes not only search and rescue missions but also mercy flights, forest fire suppression, transportation of medical teams to epidemic-threatened communities and supply of isolated and starving Eskimo bands with food and other necessities. Indeed, throughout its 35-year history the RCAF has been unique among the world's air forces for the amount of essentially non-military work which it performs. One of the bush flying jobs undertaken and started as early as 1921 has been the aerial photography of Canada.

Supplementing this work is that of many commercial operators. Best known in the field today are Hunting Aviation of Toronto, a large group of associated companies backed by British capital; Spartan Air Services of Ottawa, recently taken over by Bristol AeroIndustries Ltd.; Aero Surveys Ltd., Vancouver and Ottawa; and Lundberg Explorations Ltd., Toronto. All of these have taken advantage of extensive experience in Canada to win contracts for aerial, mapping and geophysical work on all six continents.

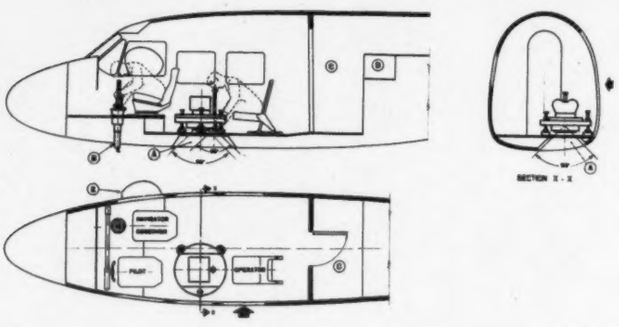
Bush flying in Canada has many faces. The traditional single-engine type of operation, for example, is far from dead. Canada's oldest air service, Wheeler Airlines, Montreal and St. Jovite, has recently sold all its large aircraft to Nordair Ltd., Montreal, and taken over the latter's fleet of small aircraft.

The rate of development of Canada's North will, however, depend on the provision of economic transportation. So it is to the use of the larger aircraft in some kind of happy marriage between bush flying and scheduled services that the northern carriers are looking in the future. Today's carriers are casting a speculative eye on such aircraft as the DHC-4 *Caribou*, the boundary layer control model of the Lockheed C-130 *Hercules* and, when suitable airstrips are prepared for it, the Canadair CL-44. ⟷

New York City from 34,600 ft: ▶

Enlarged section of a vertical photograph taken by Aero Service Corporation, of Philadelphia, Pennsylvania, with a Wild RC 9 automatic film camera for 9 × 9 in. pictures; Super Aviogon lens (f = 3.5 in.). As the original picture has been enlarged to fit this page, the scale is roughly 1 : 75,000.

Hansa Luftbild, a German firm of aerial photographers, has chosen a three-seat special version of the *Piaggio P.166* touring aircraft with two 340 h.p. Lycoming GSO-480 engines; service ceiling 25,500 ft; cruising speed 150 to 180 knots; stalling speed with flaps 64 knots; max. range in economical flight approximately 1,050 nautical miles. A. Aperture for installation of a Wild camera; B. optical sight (Williamson); C. dark room; D. stores; E. curved plastic window for downward view.



The Aircraft

Aerial photography for mapping purposes and soil surveys, geological prospecting for mines and oil, measurement of radiation and field of gravity in the air, location of schools of whales and shoals of fish, inspection of forest areas and fire fighting, the transport of building materials, the combating of epidemics, plant protection, weed-killing, top-dressing . . . clearly there is no lack of tasks for the work aircraft (and work helicopter). And the types of aircraft used are as numerous as the jobs they perform. To keep the following survey within reasonable bounds—it makes no claim to be an exhaustive catalogue—the aircraft listed have been restricted to those widely used in the two main categories of civil aerial work, namely *aerial photography* and *agricultural work*. Helicopters have also been ignored here, since they were discussed in some detail in the December 1959 issue of *Interavia*.

• Civil aircraft for aerial photography

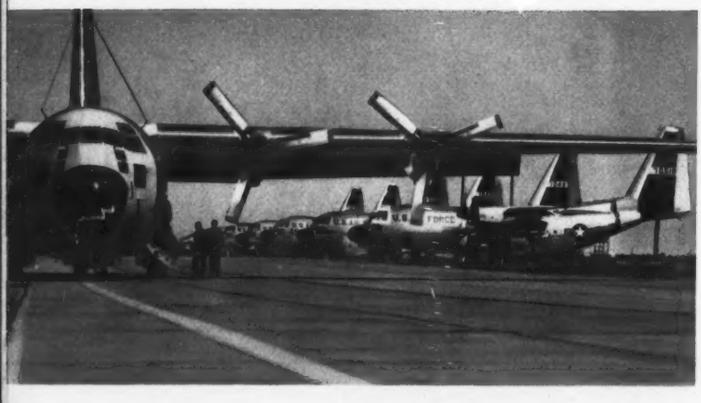
Photographic aircraft must be multi-seat and generously instrumented, capable of reaching high altitudes and covering long ranges when required, economical and stable at the moderate speeds required for photography, as foolproof as possible in low-speed, low-altitude work. These are indeed stringent requirements. Moreover, the market for photographic aircraft is a limited one, so that the development of costly special models is usually out of the question. As a rule, therefore, the civil aerial photographer must fall back on converted touring or commercial aircraft. Only the authorities of a few of the wealthier countries can afford the luxury of using the latest military aircraft—such as the Lockheed RC-130A—for peaceful aerial survey purposes.

◀ **Swissair Photo AG** uses this *Dornier Do 27* (generally flown by a two-man crew) with Wild RC8 serial camera, in particular for cadastral photography from low altitudes and in connection with road and dam projects.

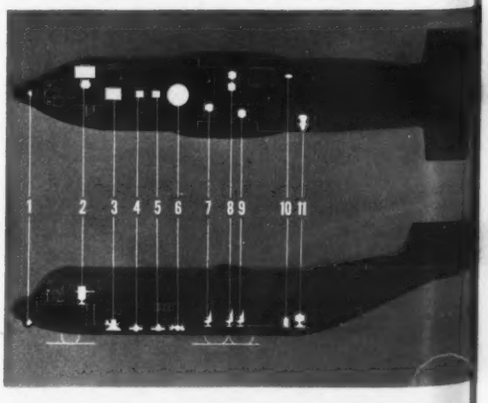
The Scottish Aviation Twin Pioneer is used in many countries as a multi-purpose aircraft—in Austria and Switzerland, for example, for aerial survey work. Picture shows a special version for geophysical prospecting (Rio Tinto) with electro-magnetic measuring equipment in the wing end plates. ▶

◀ **Percival P.54 Prince** photographic aircraft with transparent nose for the navigator. Aircraft of this type are included, for example, in the **Hunting Survey Group's** fleet, which comprises some 30 aircraft of different models (e.g., two Boeing B-17s) and is used for photographic survey and geophysical prospecting throughout the world (to date in 43 countries).

Another of **Hunting Survey Group's** work aircraft, a "good old" Douglas C-47 *Dakota* with doppler sensor and APR (Airborne Profile Recorder). ▶



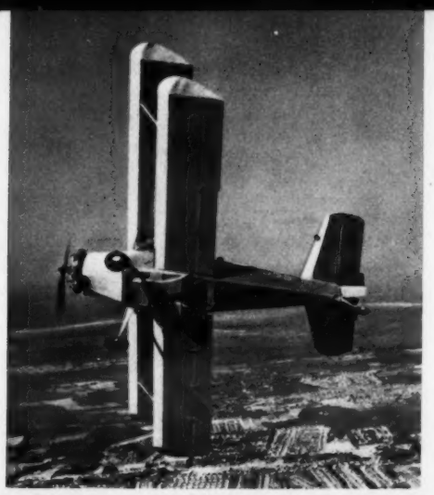
An out-and-out heavyweight among photographic aircraft is the **Lockheed RC-130A** *Hercules*. It is equipped with a whole battery of gyro-stabilized cameras, has a pressure cabin with 42-inch camera window of optical glass (weighing 320 lb), television camera, airborne profile recorder, HIRAN equipment (high-precision Shoran) etc. Fifteen aircraft of this model have been supplied to the 1370th Photo Mapping Group for MATS' Air Photographic and Charting Service. 1. Television camera; 2. photo-navigator station; 3. APR antenna (stabilized); 4. and 5. prime vertical cameras (stabilized); 6. convergent cameras; 7. Chief Photographer station; 8. HIRAN operator's station (portable); 9. APR operator station (portable); 10. radio sonde dispenser; 11. hand-held oblique camera.



for the Job

• and for agriculture

Of the some 10,000 agricultural aircraft in use throughout the world today, a good half are still converted trainers from the old days (Boeing *Stearman*, D. H. *Tiger Moth*, etc.). Specially designed models are, however, definitely becoming more popular. The market is a large one and is constantly expanding. Agricultural aircraft must be capable of spraying and dusting (and top-dressing) without major modifications and meet the following requirements: rugged construction with corrosion-proof finish, broad undercarriage, STOL capability and foolproof handling qualities (adequate engine power, harmless stall behaviour, good aileron action), excellent visibility in all directions, high payload, jettison equipment for the latter, well padded cockpit into which neither spray nor dust can penetrate, ease of maintenance and economical operation.



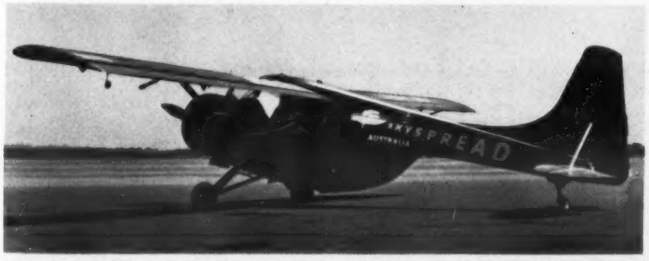
Foolproof flying qualities and good manoeuvrability are prime requirements in an agricultural aircraft. Left, an Ag-2 of **Transland Aircraft Corporation** (Torrance, California) with 600 h.p. engine; right, a Grumman *Ag-Cat* (220 h.p. engine) with dusting equipment. The Ag-2 carries up to 3,000 lb, the *Ag-Cat* up to 1,000 lb of chemicals.

Agricultural version of the German 150 h.p. **Klemm 107C** four-seat tourer. Death's heads warn of the danger of poisoning from careless handling of chemicals; windmill-driven spray pump beneath the fuselage; valves and spray nozzles well behind the wing.

Piper PA-25 *Pawnee* specialized agricultural aircraft with 150 h.p. engine. Can be equipped for spraying or dusting; gross weight 2,300 lb; useful load 1,100 lb.

The 240 h.p. **Auster** *Agricola* was also specially designed for agricultural duties. Very low-level spraying; spray tank capacity 144 Imp. gall.; dusting tank capacity 1,680 lb.

De Havilland DHC-2 *Beaver*, with 450 h.p.engine, spraying insecticides in Canada. The trees in the rear form a welcome screen against the wind, but also a dangerous obstacle.



Kingsford-Smith Aviation Service of Sidney, Australia, has fitted this Edgar Percival (Lancashire Aircraft Co.) EP.9 with a 400 h.p. *Cheetah 10* in place of the standard 295 h.p. engine.

The Czechoslovak L.60 *Brigadyr*, with 220 h.p. engine, can be equipped with either a 90-gallon spray tank or a hopper carrying 660 lb of dust; stalling speed only 28 knots.

Last but not least . . .
the indestructible **Boeing B-17** as used for aerial photography by **Hunting Survey Group**; WildRC8 serial camera and Airborne Profile Recorder; ceiling above 30,000 ft.

In a few seconds the Auster *Agricola* can jettison its entire supply of chemicals; this may be a life-saving factor in an emergency.

A Helping Hand in Agriculture and Forestry

Two incisive changes have characterized the development of cultivation techniques during the twentieth century: the displacement of the draught animal by the tractor, and the introduction of the aircraft. Although the first groping attempts to use aircraft in agriculture go back several decades, it was not until after World War II that aircraft were given major tasks in this field on a regular planned basis—and even then some countries were much slower in adopting the new methods than others. The following figures taken from a recent international report[1] give some idea of what has already been accomplished: in the United States 75 million acres were treated from the air in 1957; in New Zealand the area treated increased a hundredfold between 1949 and 1958, half a million tons of fertilizer being applied to five million acres in the year 1957/58; in Britain at least 100,000 acres of potatoes were sprayed from the air against blight during the summer of 1958. The number of aircraft used in agricultural service throughout the world is estimated at over 10,000. Of these, 200 alone are earmarked for the battle against locusts in the countries between Morocco and India. In 1955, for example, some 1,500 million locusts with a total estimated weight of 3,000 tons were destroyed over an area of roughly 300 square miles.

There can be no contesting the fact that the use of aircraft for agricultural duties is costly. The outlay, however, is repaid time and time again. The damage which insects and plant diseases cause to crops every year cannot be over-estimated, particularly as at least 40 percent of the world's population permanently suffers from under-nourishment.

Not until aircraft came on the scene could systematic and effective plant protection be achieved over wide areas. Methods and means of combating pests on the ground had scored many undeniable successes, but only on a small scale. The main advantages of the aircraft over ground equipment are as follows: maximum efficiency in the area treated per hour; low labour requirements; independence of ground conditions (e.g., heavy mud) and plant growth; no mechanical damage to crops (tractors, for example, damage up to 5 percent of a potato crop); immediate treatment at the most favourable moment. Disadvantages, on the other hand, are: dependence on weather conditions (wind conditions); difficulty of operation in the presence of ground obstructions; increased danger of harming neighbouring crops (particularly where fields are small) and farm animals; cost (on an average 50 percent higher than for ground methods).

The jobs carried out by aircraft in agriculture and forestry are many and varied; the following is an outline of the most important.

- *Spraying and dusting*
  - Plant protection chemicals (against insect pests and blights);
  - Poisons for disease-carrying insects (mosquitos, tsetse flies);
  - Fertilizers, e.g., for soil conservation, to prevent denudation by preserving the natural vegetation;
  - Special preparations for defoliation of cotton plants and potato fields prior to harvesting.
- *Seeding of rice-fields* (since long-period work in the wet fields is unhealthy for humans).
- *Scouting and inspection:*
  - Early detection of crop pests, e.g., locust swarms;
  - Detection of forest and prairie fires;
  - Inspection of herds, e.g., of animals in game reserves.
- *Transport work*
  - Transporting crews and equipment to the scene of a fire, and recently direct fire-fighting from the air by spraying;
  - Dropping of poisoned bait to exterminate larger pests, e.g., rabbits.

By far the biggest of these jobs is pest control.

An essential requirement for systematic pest control from the air is the *cooperation of a team of qualified experts*. There are tasks for not only the agricultural expert, but also for the biologist, in particular the botanist and entomologist, the expert in organic and physical chemistry, the meteorologist, the engineer and above all the experienced pilot with special training in agricultural flying.

The *agricultural expert* must be thoroughly acquainted with not only the botanical side of plant protection, but also the possibilities and limitations of the various methods of treatment. Every crop has its own particular enemies, and a different destructive agent and a different method should be used for each in order to obtain the best results. In addition, the agronomist must create the best possible conditions for the efficient and economical employment of aircraft, by far-sighted planning of his crops.

The *biologist* helps in the selection of pesticides and decides upon the quantities to be used and the best moment for using them. Some preparations, while fatal to one pest, cause others to flourish. For instance, the *Epilachna corrupta*

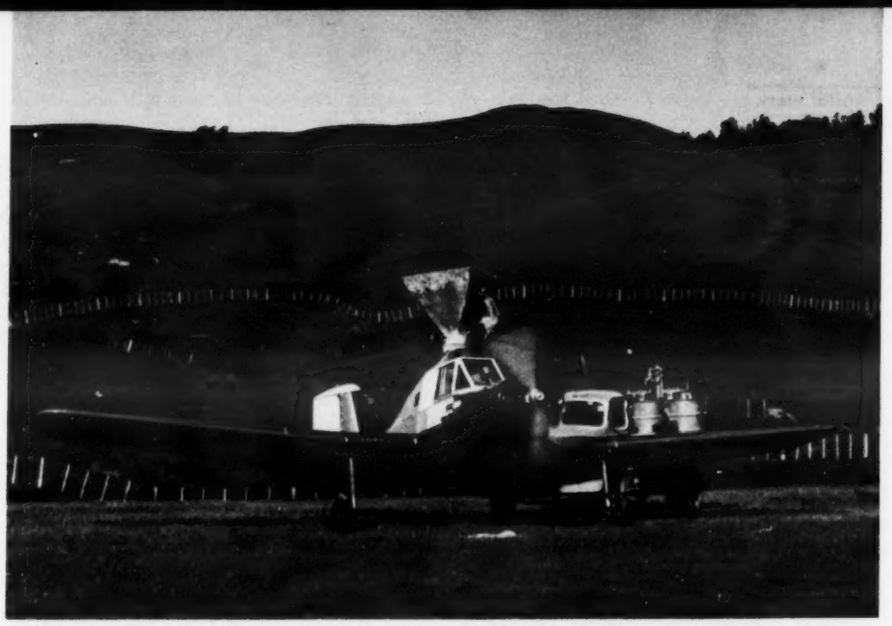
A Transland Ag-2 dusting cotton-fields with a swath of pest-killer approximately 80 ft wide on each passage. To speed the harvest the cotton-plants are also stripped from the air.

[1] "Meteorological Service for Aircraft Employed in Agriculture and Forestry." Report of the Working Group of the Commission for Agricultural Meteorology, 1960.

(Mexican bean beetle) thrives happily on grasshopper poison. Many insects must be attacked during the few days when they are most vulnerable; in the case of the spruce budworm, for example, this period is just ten days.

The *chemist's* responsibility is to develop suitable pesticides. Aircraft spraying and dusting necessitate special preparations in highly concentrated form. For *insecticides* a dosage of $^1/_2$ to 1 gallon per acre, depending on product, should suffice since insects move about among the plants and so come into contact with the poison even if the latter is not spread in a continuous layer. *Herbicides* (weedkillers) have been used successfully from the air on grain fields in dosages of around 1 gallon per acre. *Fungicides* must be applied in a close layer, otherwise certain patches may remain untreated. This necessitates either large dosages or repeated spraying. The chemist here has a rewarding field of endeavour.

There are four kinds of plant protection substances, classified according to their physical properties as solutions, emulsions, suspensions and dusts. While emulsions and suspensions sometimes show a tendency to separate and must be kept in constant motion during spraying, solutions are pure liquids and present no special problems. Altogether today the general trend is towards spraying rather than dusting. Liquids can be distributed evenly through nozzles arranged along the whole span and generally stick to the plants better than powders. The evenness and density of the layer of active ingredients depend primarily on the behaviour of the chemicals after release from the aircraft, which in turn is determined by a number of different factors, some of which cannot be controlled: particle size, concentration, electro-static charge, wind direction and speed, ambient temperature, atmospheric humidity, etc. Some spray mixtures require light, steady winds, while others must be applied in zero wind; one preparation adheres to wet leaves, another to dry; light rain can sometimes be an advantage, but lengthy rainfall washes the pesticides off the plants. *Accurate forecasting of local weather conditions near the ground is thus of decisive importance.* However, except for very large-scale operations, it has not been usual practice to employ a meteorologist, less from reasons of economy (which would be misplaced) than because of the shortage of agriculturally trained meteorologists. On the other hand, the farmer generally has detailed knowledge of local weather conditions handed down from generation to generation.



Preparing for top-dressing in New Zealand. As the motor runs, the chemical tank of an Auster *Agricola* is filled by a rapid loading device.

Spraying equipment of a Transland Ag-2: The windmill-driven pump transfers the liquid to be sprayed from the fuselage container (capacity 395 U.S. gall.) via a pilot-controlled regulator valve to the nozzles. Wire cutter blades attached to the landing gear sever electric wires, the agricultural flyer's number one enemy.

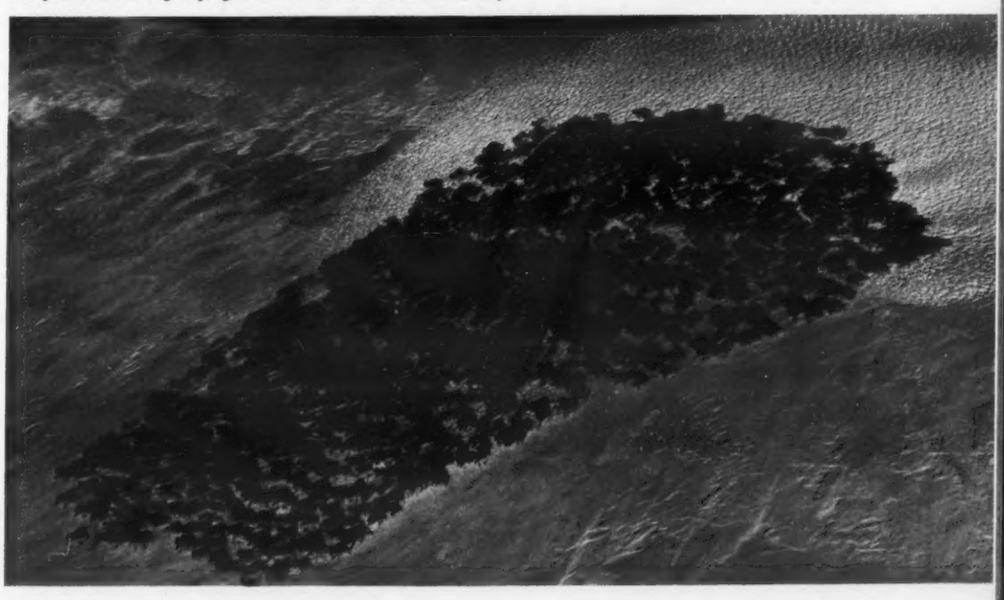
To the *engineer* fall both design and organizational duties in aerial farming. The full benefits of avio-chemical methods can be obtained only if special aircraft are used. In the early days after World War II the only aircraft available were from surplus army stocks, and the wide variety of types used, together in many cases with their unsuitability for the task, often led to accidents or unsatisfactory results. Understandably, therefore, as demand increased, more and more aircraft manufacturers turned to the design of specialized types. Despite the attractive flying qualities of the helicopter, the aircraft used in agricultural service are almost all fixed-wing models. The main objection to the use of helicopters on any large scale is one of cost, though there are some cases where a rotary-wing aircraft is the only answer: in very broken country, for example, or areas where there is no suitable landing strip, or again where the vegetation is so dense that the rotor downwash is required to enable the spray to penetrate adequately.

The most thankless task in pest control falls to the pilot. The difficulties and dangers of aerial spraying and dusting have been described by R. C. Amsden as follows[2].

"A man who is flying a light aeroplane some 5 to 12 ft above a crop at 40 to 80 miles per hour has a full-time job just flying. He is all the time sensing air movements through the controls, listening to his engine, checking the airspeed, keeping one eye on fixed obstacles, such as trees and overhead wires and the other eye open for moving objects such as birds and other aircraft. These things are vital to his survival, and he has several important gauges to check at intervals—spray pressure gauge, tank contents gauge, oil pressure gauge, fuel level, etc. etc. . . . At the end of the run he has to shut off the spray, not too late or he will be wasting spray chemical and thus precious spraying time. In all this he must make due allowance for temporary changes of both wind speed and direction, adjusting his height and position accordingly. In pulling up out of the crop he has to accelerate, climb over the trees, turn into wind—not banking too steeply or the part-filled spray tank may take control of the aircraft. Then he must line his aircraft up for the next run, throttle back and turn on the spray cock just as he lowers himself over the trees."

[2] "Aircraft in Agriculture." Report of Eighth National Power Farming Conference, Harrogate, England, 1959.

Only the aerial photograph has made it possible to accurately spot wandering herds of animals in uninhabited regions. The picture shows a galloping herd of reindeer in northern Norway.



Aerial work

Aircraft in the Service of the Collective Farm

By P. N. Chulkov, Administrative Head, Aeroflot

A substantial proportion of the Soviet civil aviation programme is devoted to so-called "special applications," also known as "light aviation," for which lighter aircraft, such as the An-2, the Yak-12 and similar types are used. In agriculture, for instance, the aircraft has become such a popular aid that it is now in daily demand. This branch of Soviet aviation underwent a long and careful preparation, for as early as 1922 the experimental air station near Moscow was the first in the world to study methods of spraying liquids from the air. Later, swarms of locusts were wiped out with poison dust. Scientists and pilots joined forces to plan a spraying and dusting programme and invented special equipment for the extermination of plant pests and malarial mosquitoes.

These systematic preparations led in the thirties to the regular use of aircraft in agriculture. Throughout the Soviet Union there arose air work units which proved highly effective aids to farming. Their activities were helped by the collectivization of the land, for in those years the last small properties disappeared and the aircraft could operate freely over the vast areas of the collective farms.

In the decade before the USSR became involved in the Second World War (1931 to 1941) the main breeding grounds of the Asiatic locust were wiped out, and great success was achieved in the struggle against the other pests and plant diseases which plague agriculture and forestry. By the end of this period the total area treated from the air was nearly 62 million acres.

After the war spraying and dusting operations rapidly increased. In 1953 alone nearly 15 million acres were covered, and today this figure has been trebled.

In terrain where ground transport is difficult, aerial treatment is the most effective, and in many cases the only way of killing pests and weeds. Furthermore, agricultural flying has proved the most productive and in all respects the most economical method. The aircraft can do the same work as a horse- or tractor-drawn spray or atomizer ten times as fast and effectively and at considerably lower cost.

Aircraft are at present being used in a series of operations designed to improve the yield of a variety of crops: spraying artificial manure, fertilizing winter crops, chemical stripping and drying of cotton plants etc. The following are some examples of achievements during 1959.

In Estonia winter crops and perennial grasses were fertilized from aircraft in early spring, when the ground was still too soft for them to be treated by ground vehicles or by hand. Aircraft also spread fertilizer on the spring seed and potatoes, and in June they sprayed weed-killer on the maize fields. These services contributed in a considerable degree towards the high crop yield on the collective farms of the Estonian Republic.

In Siberia, Kazakhstan and other regions, the top-dressing of cereals and weed-killing operations were carried out from the air. This enabled the yield to be raised by 700 to 1,100 lb per acre.

An innovation in 1959 was the top-dressing of vineyards in the Crimea, which resulted in a yield increase of 500 to 700 lb per acre and a rise in the sugar content of the grapes.

The favourable climate in some of the Soviet Republics enables aerial spraying and dusting to be carried on throughout the year. In Azerbaidjan, for instance, work begins in spring with the fertilization of cereals and the extermination of rodents, pests and weeds. In the summer the aircraft combat the boll weevil, in the autumn they strip the cotton-plants and in the winter they dust vineyards and market gardens. And so the work cycle continues without a pause until the next spring.

In the cotton plantations of Tadzhikistan, too, the air is ahum with the noise of propellers. The surface treated from the air measures 500,000 acres, and the cotton-pickers in this tiny Republic hope to raise the yield of "white gold" to one million tons in 1960.

Even in the Far North of the Soviet Union aircraft are used for agricultural purposes. As early as March, An-2 aircraft, fitted with skis, scatter ashes, soot, finely crumbled earth and other dark materials over the fields of the collective farms near Archangel to speed the thaw by two to three weeks. In these sub-Arctic areas any time gained is, of course, of decisive importance in the success of the sowing. Furthermore, the so-called "blackening of the fields" enables the humidity of the soil to be maintained in hilly country.

On a number of collective farms in the Archangel region the meadows are sprayed with a 4 percent salt solution. The salted grass improves the appetite of the cattle and raises their water intake; this in its turn increases the milk yield by 10 to 15 percent.

In the field of forestry, almost 90 percent of all forest fires are reported by aircraft which make routine patrols and parachute firemen into the danger zones. Experiments are now being conducted with a view to localizing and extinguishing forest fires directly from the aircraft. A special apparatus sprays fire extinguisher from a height of 150 feet and prevents the fire from spreading.

The Soviet Ministry of Agriculture intends to treble aerial dusting and spraying operations under the current Seven Year Plan, so that about 125 million acres of land will be under treatment by 1965.

Scientific research is at present concentrated on means of perfecting equipment for the chemical treatment of cultivated and wooded areas. Much attention is also being devoted to the development of chemical concentrates with high effectiveness and low consumption per unit of the area to be treated. ◆◆

The Soviet Antonov An-2 *Kolkhoznik* agricultural aircraft.

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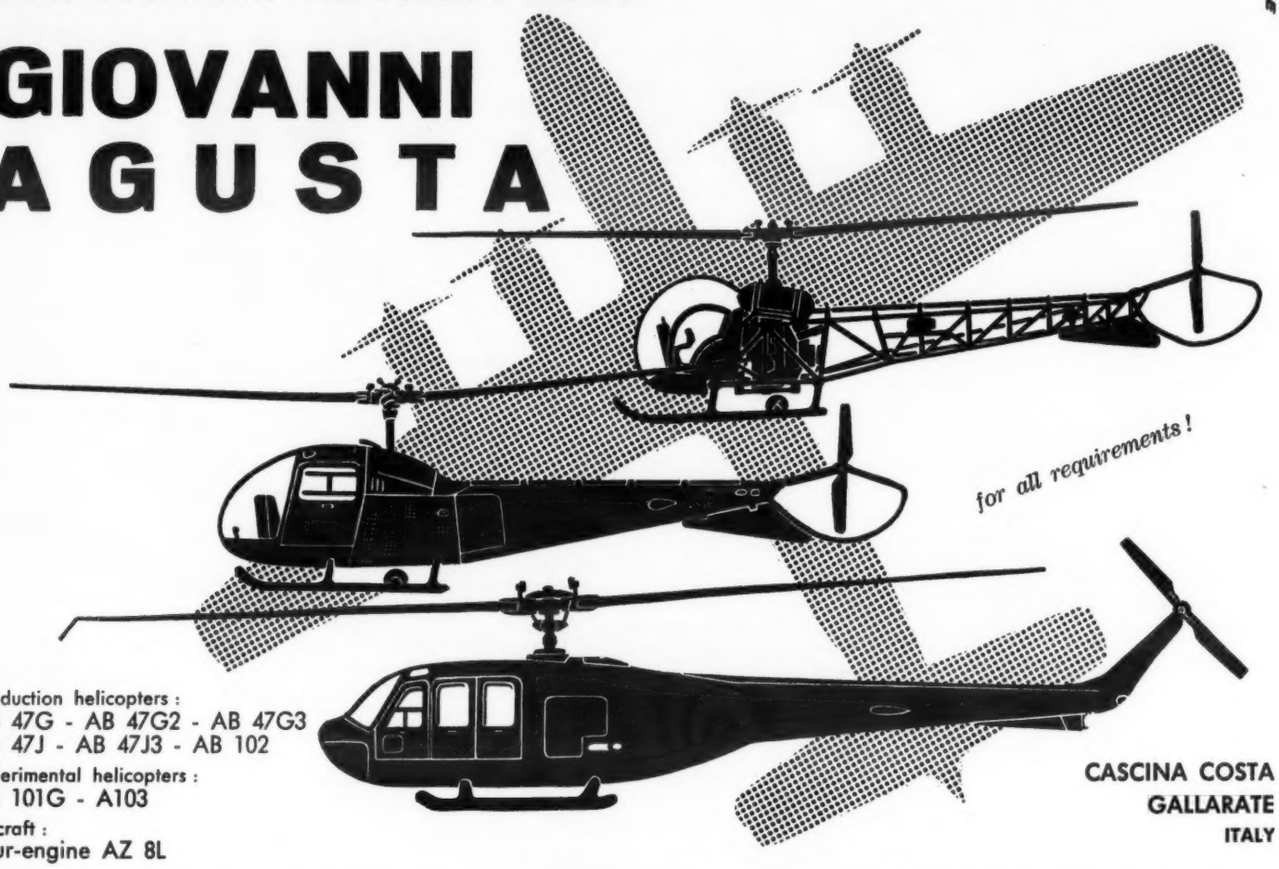

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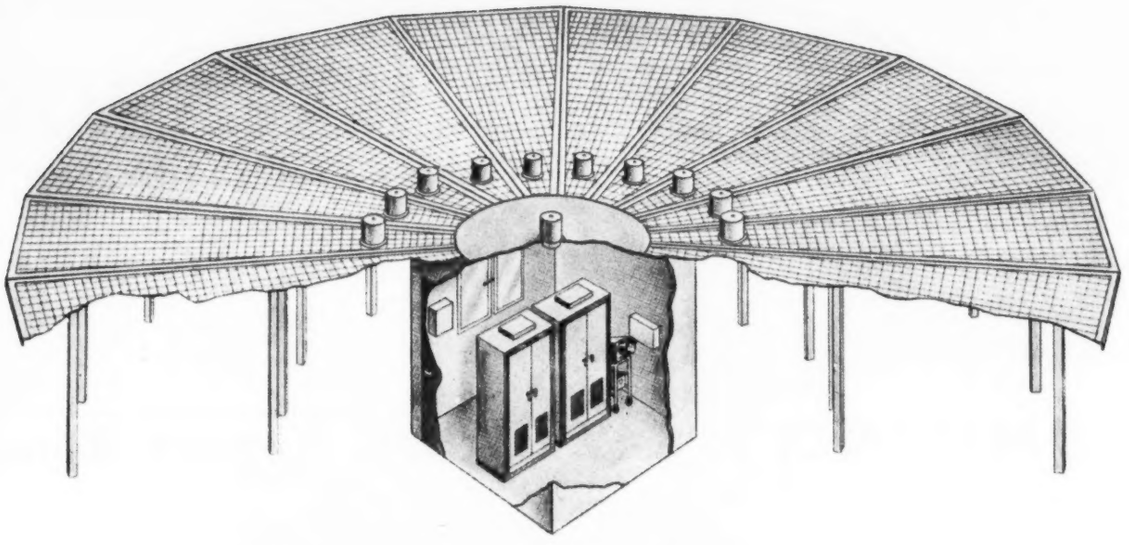
Dr. Andrea Zavitteri, Architect
Dr. Amedeo Luccichenti, Architect
Dr. Vincenzo Monaco, Architect



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Fiumicino and Airport Policy

By Giuseppe Togni, Minister of Public Works, Rome

Since the official inauguration of its new intercontinental airport on the Tyrrhenian Sea on June 2nd, 1960, Rome has possessed two large modern airports ready to meet all the requirements of jet age traffic. On the date mentioned Alitalia opened a direct Fiumicino–New York service with Douglas DC-8s. Other carriers are expected to follow the Italian company's lead in the near future and likewise route their international services via Fiumicino. While Ciampino will continue to handle both military and civil traffic, Fiumicino has right from the start been designed exclusively for civil aviation. The airport received its "unofficial" inauguration a month ago, when a British Viking *aircraft on charter had to be diverted to Fiumicino on May 9th because of fog at Ciampino.*

Interavia, *which has from the beginning recognized the significance of the Eternal City's impressive airport project (cf. Engineer G. Amici's two articles in No. 10/1954 and No. 7/1955), is happy to present its readers with a report from an authoritative pen on the final phase of construction. In his three years as Minister of Public Works, the author, the Right Honourable Giuseppe Togni, has played an important part in the construction of Italy's most modern airport, which has been given the name of* Leonardo da Vinci, *painter, architect, natural scientist and engineer.*

Born at Pontedera near Pisa on December 5th, 1903, Giuseppe Togni studied political science and became lecturer in labour jurisprudence at Rome University. After the war he was elected to the Constitutive Assembly as a member of the Christian Democratic Party, and from 1947 onwards he held the offices of Under-Secretary of State for Labour and Social Welfare, Minister of Trade and Industry, Minister of Transport and Minister of State Participation. Since 1957 he has headed the Ministry of Public Works, which is responsible for the planning, contracting and supervision of all construction work on the airport. *Eds.*

In a modern and highly-developed nation with a genuine desire to progress along the path of civilization and social welfare, the role of air transport is of considerable, and often decisive importance.

The writer is not among those who hold the short-sighted and somewhat Utopian view that normal means of communication will, in the more or less near future, be supplanted by the aircraft, whether it be piston-engine, turbine-powered or nuclear-powered; nevertheless, he fully concurs with the experts who acknowledge the growing importance and unrivalled usefulness of the aircraft as a means of rapid communication, shortening distances between countries, developing contacts between the nations and multiplying exchanges in the industrial, commercial, cultural and social fields.

Rome-Fiumicino control tower and flight advisory service.

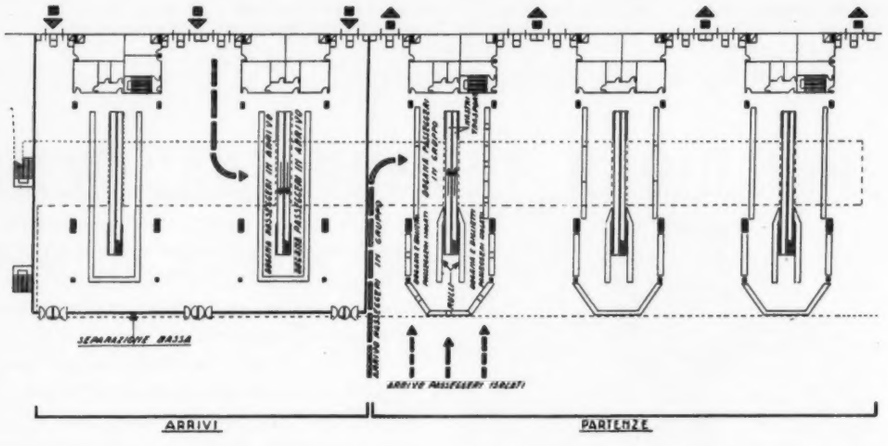
Seen from the control tower: the four-storey terminal building and its two fingers, leading to 28 aircraft stands.

To cope with this constant development of air traffic and the impressive volume which the latest technical advances will enable it to reach in a very few years, our Government some time ago decided to consider renewing the structure and organization of ground facilities in Italy, a country which has always been sympathetic to the development of aviation, even though her economic resources have not always permitted her to turn her ambitions into practical reality.

In this task of renewal and reorganization the Ministry of Public Works has put its shoulder to the wheel resolutely and energetically, particularly in the last few years; the number of projects at present under construction or completion will very shortly give Italy a complete network of new airports and modern equipment. This will enable her to compete on an equal footing with the most advanced nations in this field, and meet not only present and future requirements for domestic operations—at any rate for the next half-century—but also those of international traffic, which is attracted as much by the efficiency and rational design of the installations as by the fortunate geographical position of our country.

In preparing the technical and administrative facilities to carry out the imposing task of modernization and extension, it has been the chief preoccupation of the Christian Democratic Government, and of the writer in particular, to lay down a plan of progressive development following certain guiding lines. These can be briefly outlined as follows: a careful examination of present facilities and foreseeable development of existing airports;

View of the apron in front of the terminal building during the last stage of construction.



Plan of the passenger floor of the terminal building, about 20 ft above ground. There are four customs channels for arrivals, and two to six for departing passengers. Here passengers' luggage is brought up from the lower floor on moving belts and passed to the customs for inspection.

the improvement and modernization of existing installations, and the possibilities of enlarging them; a careful choice of time and site for the construction of new airports so as to avoid unproductive expenses or outlay which does not bring in immediate returns. In other words the Government must take account of rapid technical progress and future developments and, while proceeding with the maximum energy and diligence, must take every precaution to avoid financial surprises.

Having clearly outlined what we feel to be the most appropriate policy as regards aviation ground facilities, we can give the assurance that we are doing everything possible to equip them to meet future requirements as quickly as our economic resources will allow.

The intercontinental airport of Fiumicino bears unmistakable testimony to our intentions and our endeavours. The thorough and painstaking preparatory studies begun over ten years ago were undertaken in collaboration with the Ministry of Defence (Air) with due regard to developments in aeronautics and the fact that airways are destined to assume an ever-increasing importance in the fields of politics, social life, tourism and commerce. The Ministry of Public Works, which was entrusted with the execution of the project, has put the work in hand vigorously: today Fiumicino Intercontinental Airport can be considered practically complete, and when it becomes operational in time for this summer's Olympic Games at Rome, it will be one of the most technically advanced intercontinental ports of call.

In this connection a few technical data may be of interest. The choice of the site was dictated by the flatness of the terrain which extends over a radius of more than six miles inland, is exposed to moderate winds and is hence sheltered from the fogs which present such hazards to commercial aviation. Another major advantage of the site lies in its proximity to Rome—just over 12 miles as the crow flies.

Model of the terminal building, its fingers and the aircraft stands.

Front of the terminal building with extensive car park.

Four Douglas DC-8s can be accommodated side by side in this maintenance hangar.

Outside of the maintenance hangar. The roof is supported by 30 T-shaped cantilever beams; the doors can be slid back over their entire width.

The airport was designed to handle 6,000 incoming and outgoing passengers daily, travelling on 400 aircraft, of which 320 would be intercontinental.

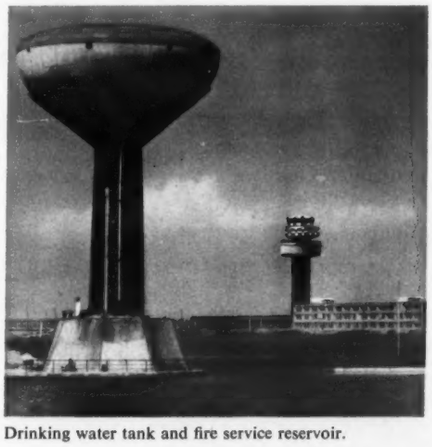
The main problems which had to be solved can be broadly outlined as follows:

1. The subsoil water had to be kept within reasonable limits so as not to alter the consistency of the alluvial deposits;
2. an ideal camber had to be found for the entire paved area of the airport to drain off rain water (as much as 7 inches can fall in four hours), in view of the level of the subsoil water, which is only 3 feet below the surface.

These requirements meant that about 160 million cubic feet of earth had to be brought from eight miles away; two pumping stations with a combined power of 1,300 h. p. and a pumping rate of 600 cu. ft./sec had to be set up, not to mention a network of drains and collectors with a total length of 22 miles.

The main structural elements are:

1. Two concrete runways almost perpendicular to each other, running in the directions of the prevailing winds, with respective lengths of 13,000 and 8,670 ft and a useful width of 200 ft. with parallel concrete taxiways 100 ft wide and 13 inches thick.
2. Taxi tracks with a total length of 15,000 ft and similar characteristics to those of the parallel taxiways, enabling aircraft to reach the aprons in front of the terminal building and the hangars. Runways, taxiways and aprons are equipped with the necessary lighting installations for the guidance of aircraft.
3. A terminal building with an overall volume of 12 million cu.ft., including a 180-ft control tower and an air traffic control centre.
4. A hangar to take four aircraft, of advanced design and tubular steel structure, with a clear width of 165 ft and a volume of 11,475,000 cu. ft., including offices, storage space and workshops.
5. A number of other airport buildings, including bonded warehouses, fire station, emergency technical services, military accommodation and car park, covering an area of about 150,000 sq. ft.
6. A building housing electronic aids for instrument landings and special meteorological equipment.

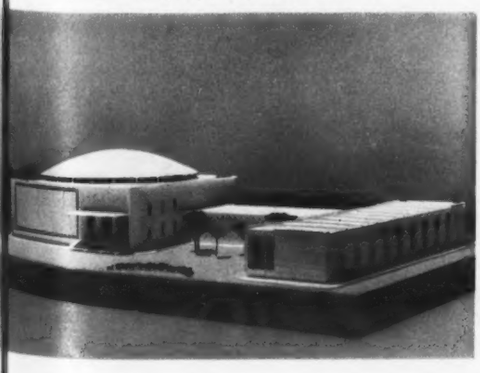


Drinking water tank and fire service reservoir.

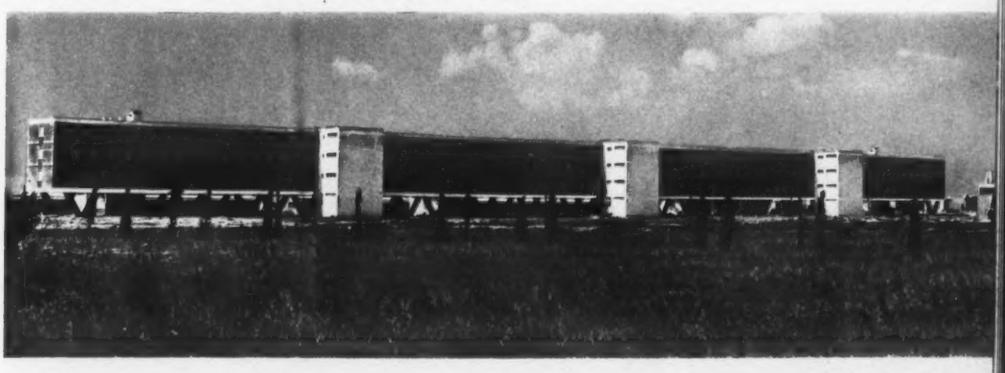
Fiumicino is reached by a motor road from the Via del Mare to the airport itself, over a reinforced concrete viaduct about 4,300 ft long, which passes over the River Fiumicino and the excavation site.

In addition, the airport will be linked with the Rome Termini station by a double-track underground railway. Here a number of thorny technical problems will have to be solved, particularly in connection with the construction of the railway station next to the airport terminal building, which will penetrate nearly 12 ft into the subsoil water.

Model of the church, which will be available to all denominations, and of the social centre.



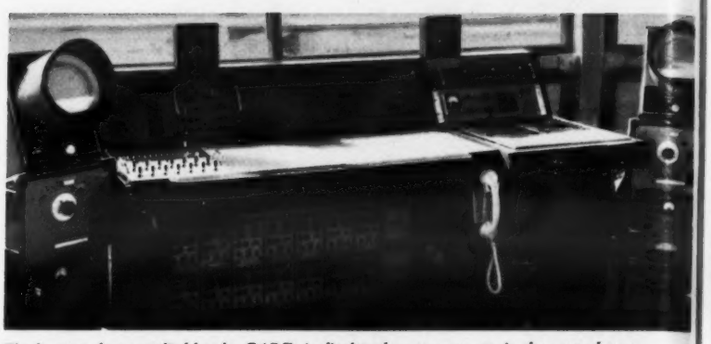
Living quarters for customs officers, airport police and airport guards.



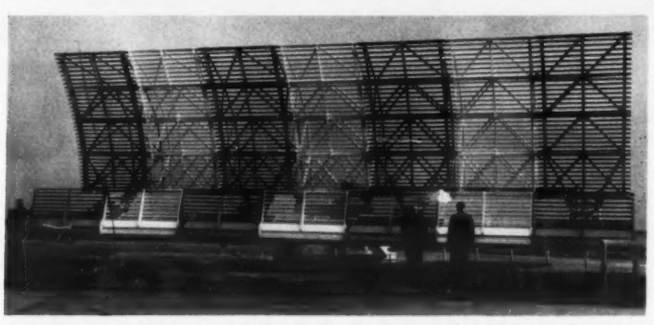
The Air Traffic Control Equipment at Rome-Fiumicino

Rome's new intercontinental airport is equipped with the most modern aids to communication and navigation, including:

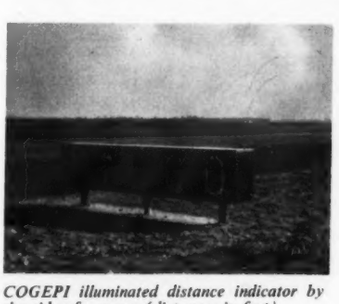
1. Information centre with teleprinter and telephone connections and all equipment necessary for ground-air voice radio communications in the HF and VHF bands (UHF to be installed shortly); separate transmitter and receiver antennas (see diagram).
2. VOR rotating beacon of American design (has been in operation for some time).
3. Commutated Antenna Direction Finding Equipment (CADF) by FACE Standard, Milan (and its British associate Standard Telephones and Cables), for simultaneous operation on two VHF frequencies, later to be increased to four VHF frequencies with two UHF frequencies. The CADF stands near the ILS middle marker on the north-south runway approach and is connected by telephone cable with the displays installed in the control tower.
4. FACE Standard/Standard Telephones and Cables instrument landing system for north-south approach: localizer and glide path transmitter and fan markers.
5. PAR-3 precision approach radar, built by Telefunken and FIAR (Fabbrica Italiana Apparecchi Radio). The aerial array, set up near the intersection point of two runways, is turned in the chosen direction of approach (3 possibilities) by remote control.
6. Marconi Type S.264 surveillance radar with short-range (up to 40 n. m.) and long-range (up to 160 n. m.) presentation on eleven displays by microwave radar link. The use of the 50 cm wavelength and an efficient moving target indicator gives a radar picture practically free of clutter.
7. A complete airport lighting system by COGEPI (Compagnia Generale Progettazioni e Installazioni) with a total 2,046 lights and a power consumption of 235 kW. Taxiway and runway lighting, including threshold and touch-down point lights; two high-intensity approach lighting (Calvert) systems for approaches from north and east; simple identification of the extended runway centre line in the two opposite approach directions; electronic flashing lights for north-south approaches with 20 xenon lamps (duration of flash 1/5,000 sec, intensity 30 million candles). There are glide-path indicators in three colours at each end of the two runways.



The bearing data supplied by the CADFs is displayed on two screens in the control tower and is easily distinguishable even in daylight. The equipment can operate simultaneously on any two frequencies out of a total of 10.



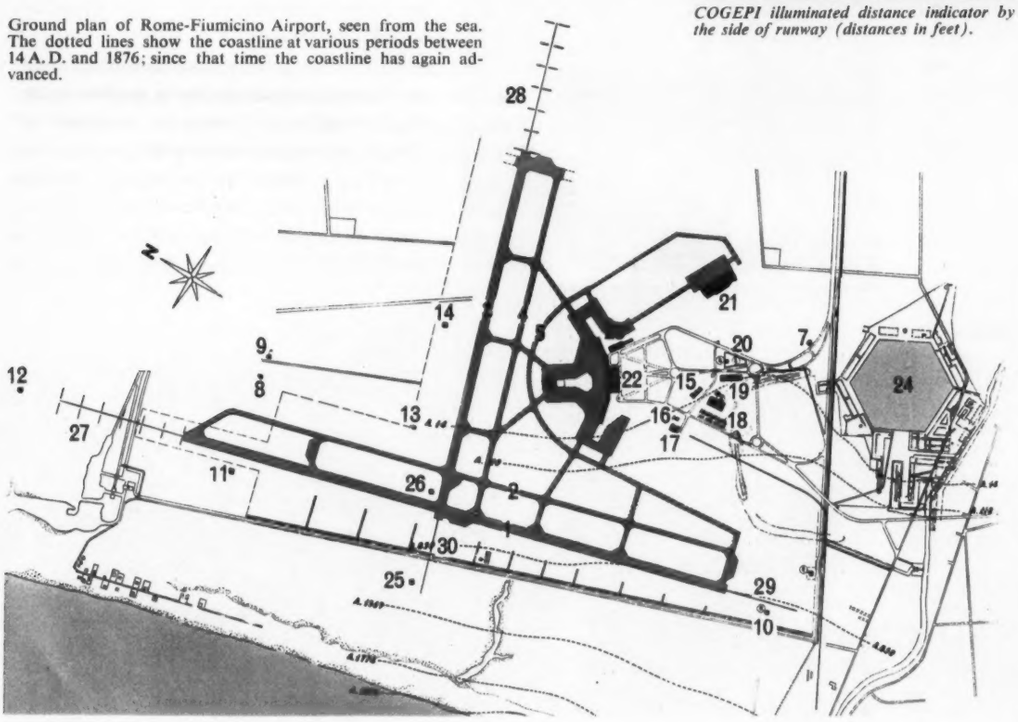
Antenna of an S.264 surveillance radar of the kind in operated at Fiumicino. Transmitter and receiver are mounted beneath the antenna in a watertight compartment.



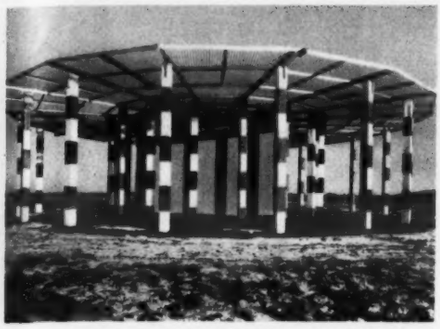
COGEPI illuminated distance indicator by the side of runway (distances in feet).

High- and low-intensity lamps for the COGEPI runway lighting system.

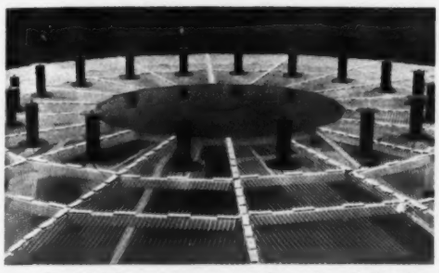
Ground plan of Rome-Fiumicino Airport, seen from the sea. The dotted lines show the coastline at various periods between 14 A.D. and 1876; since that time the coastline has again advanced.



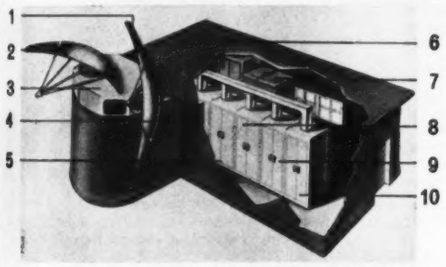
1 North-south runway (runway No. 1)
2 Taxiway No. 1
3 East-west runway (runway No. 2)
4 Taxiway No. 2
5 Taxi tracks
6 Apron in front of terminal building
7 Transmitter building (with antennas)
8 Receiver building (with antennas)
9 Meteorological station (radio sondes)
10 ILS localizer
11 ILS glide path transmitter
12 Middle marker beacon and CADF
13 VOR rotating beacon
14 Fire and rescue service
15 Airport administration
16 Church
17 Technical assistance service
18 Living quarters
19 Water purification plant
20 Drinking water tank and fire service reservoir
21 Maintenance hangar
22 Terminal building
23 Control tower and flight advisory service
24 Porto di Traiano (harbour built by the Emperor Trajan, today an ornamental lake)
25 Surveillance radar
26 Precision approach radar
27 North-south approach lighting
28 East-west approach lighting
29 Lights for identifying the extended runway centre line for approaches from the south
30 ditto, for approaches from the west



The counterpoise of the CADF antenna, which is of steel mesh construction and 45 ft in diameter, reduces the "cone confusion" above the station.



The 18 VHF antennas, arranged in a ring 13 ft in diameter, are successively scanned by a receiver for 1 millisecond each. The desired bearing is obtained by comparing the phase of the transmission from the aircraft with a fixed reference phase.



PAR-3 transmitter/receiver building: 1 – heightfinding antenna; 2 – directional antenna; 3 – antenna cabin; 4 – power unit; 5 – transmitter/receiver; 6 – mains connection; 7 – voltage regulator; 8 – control unit; 9 – second transmitter/receiver; 10 – second power unit.

Antenna array of a Telefunken-FIAR PAR-3 precision approach radar.

The fingers leading from the terminal building are 20 ft above ground and are exceptionally spacious; ramps at each side lead to the aircraft.

The rate of arrivals and departures, at intervals of barely twenty minutes (travelling time between city and airport), will permit the rapid transport of passengers, visitors and airport personnel.

The Ministry of Public Works will be responsible for building the underground railway serving the airport; funds will be advanced for the purpose by the Ministry of Transport, which will later be reimbursed.

The interior of the airport is served by a network of well-lit roads with a total length of over six miles.

All the electrical systems are connected with cabins distributed throughout the airport and fed in the normal way from external power supplies. An emergency power station has been constructed in order to maintain services in the event of grid failure. The peak power at present required is 16,000 kVA.

Such, in brief, are the basic characteristics of the facilities. Despite the technical and economic difficulties which have had to be overcome, the effort put into the work since 1958 has been considerable, for in less than two years the airport buildings, including the great terminal building, have been completed, and the complex electrical and electronic equipment and air traffic control and navigational aids, such as radar, ILS and VOR, have been installed. All this work has required considerable financial resources and the employment of a vast force of both intellectual and manual workers.

The cost of the work so far completed amounts to 26,500 million lire ($42,742,000), of which nearly half has been spent since 1958.

For Rome and for the whole of Italy, Fiumicino Intercontinental Airport is a magic door to the world and to the future. ↔

Motor road leading from the Via del Mare.

What's in the Air?

Northrop N-156F for Spain? A delegation from the Spanish Air Ministry, headed by Colonel Vicente Sintes (centre), and representatives of the Spanish aircraft industry recently visited American aircraft works near Los Angeles. Among the subjects discussed was that of military and economic cooperation between the USA and Spain. Left: Lieut.-General Patrick W. Timberlake, Vice-President of Northrop Corporation; right: Lieut.-Colonel Daniel A. Cooper, Head of the Los Angeles Air Procurement District.

INDUSTRY

● **Bristol Siddeley Engines Ltd.** has signed an agreement with the Italian Piaggio company, of Genoa, covering the licence production and sale in Italy of the Bristol Siddeley *Viper 11* turbojet engine. The British company's *Viper 11* (thrust 2,500 lb) powers the Macchi MB.326 standard primary trainer for the Italian Air Force, and Piaggio will manufacture the engine for this aircraft. Bristol Siddeley now has the *Viper* in large-scale production in two versions: the 1,750 lb thrust *Viper 8* powering the Hunting *Jet Provost Mk.3* trainer for the Royal Air Force, and the *Viper 11* which powers the Australian *Jindivik Mk.3* drone. Later models of the *Jet Provost Mk.3* will also be equipped with the *Viper 11*.

Bristol Siddeley already has a licence agreement with Fiat for production of the *Orpheus* turbojet for the Fiat G.91 light strike fighter. In 1953, Marcel Dassault acquired licence rights to manufacture the *Viper* in France and developed the R.7 *Farandole* version. Marcel Dassault designated the *Viper* "MD.30" and, although the unit originally found application in the SO.9050 *Trident II* and the MD.550 *Mirage I* research interceptor, little has been heard of further French development or utilization of the engine for some time.

● **A.V. Roe (Canada) Ltd.** has announced the appointment of Douglas Edwards, formerly RCAF Air Attaché to the Canadian Embassy in Bonn, as Technical Sales Manager for the A.V. Roe Aeronautical Group Ltd. Edwards will represent Avro Aircraft Ltd., Orenda Engines Ltd., Canadian Applied Research Ltd. and Canadian Steel Improvement Ltd. (all of Toronto) and will establish a Group European Headquarters in Bonn, West Germany.

● **Fluggerätewerk Bodensee GmbH,** a subsidiary of Bodenseewerk Perkin Elmer & Co. GmbH, is setting

The first of Swissair's SE.210 Caravelle *medium-range jet airliners will go into service on the Zurich–London route on May 21st. Delivery of the remaining three* Caravelles *is scheduled for the end of June and the beginning of July.*

During his trip to France British Aviation Minister Duncan Sandys (left) visited Sud-Aviation's Toulouse plant, where he was received by Sud-Aviation President Georges Héreil (right).

The prototype of the Avro 748 short- and medium-range airliner, powered by two Rolls-Royce Darts, *is nearing completion.*

up new manufacturing facilities at Überlingen for licence production of the *Sidewinder* air-to-air missile. The *Sidewinder*, together with the M-61 cannon, is standard equipment for the European F-104G programme. The parent company is main coordinator for the NATO *Sidewinder* programme, and has reportedly received contracts totalling DM 130 million ($30 million) for production of some 8,000 missiles for NATO, in cooperation with other manufacturers in Norway, Denmark, Greece, the Netherlands and Turkey.

● **Short Brothers & Harland** has announced conclusion of an agreement in principle with Focke-Wulf GmbH, under which the Short *Seacat* sea-to-air missile, originally developed for the Royal Navy, is to be evaluated by the West German Armed Forces with a view to possible orders. Initially Focke-Wulf will be responsible for the test programme, and a subsequent programme of joint development by the two companies is envisaged if the tests prove that the missile is suitable for German requirements. Short Brothers & Harland is studying the *Tigercat* variant of the *Seacat* for ground artillery roles.

● **Sikorsky and Mitsubishi** have concluded an agreement whereby the Japanese firm obtains manufacturing and sales rights for the civil and military versions of the Sikorsky S-61 turbine-powered helicopter for Japan and other markets in Asia.

Orly at night. In the background is the structure of the future terminal building. The extended main runway at Orly, now 10,000 ft long, has been in operation since November, 1959.

● **Georges Hérail,** President and Managing Director of Sud-Aviation, has been made a Commander of the French Legion of Honour.

● **First deliveries of the 50 Fiat G.91s** to be supplied by Italy under the West German Air Force's procurement programme are scheduled for this month and will continue up to April 1961. Fiat will begin delivery of the 20 G.91 trainers in the spring of 1961, and this batch will be completed by the summer of that year. The West German industry's Southern Group (Dornier, Heinkel and Messerschmitt) is due to commence delivery of the first licence production models in the summer of 1961, with the full order for 232 aircraft scheduled for completion within three years, that is by the summer of 1964. No date has yet been announced for initial deliveries of the Bristol Siddeley BOr.803 engines to be manufactured under licence by Klöckner-Humboldt-Deutz at the Oberursel/Taunus plant. Equipment for the German-built G.91s is to be supplied by manufacturers in various NATO countries.

● **Boeing Airplane Company** is to build eleven *Dyna-Soar* gliders under a USAF programme announced on April 27th; three will be built for ground tests, four for unmanned flight, and four for manned flight. The *Dyna-Soar* will be boosted into orbit by a Martin *Titan*.

● **Compagnie Générale de Télégraphie sans Fil** (CSF) has acquired a majority holding in the Italian company of Ducati Elettronica, which has its offices and plant at Bologna. Ducati is engaged in large-scale production of components for the electronics industry (particularly condensers), and its manufacturing facilities will form a useful addition to the production capacity which CSF already has in France and Italy. In 1959 CSF's turnover was up 41 percent on the preceding year.

Lockheed is building a wind tunnel for flow speeds of up to Mach 5 at its new Saugus, California, research centre. From this summer onwards the tunnel will be used for testing models of future aircraft and missiles.

MILITARY AFFAIRS

● **The British Government** has reportedly decided not to proceed with development of the *Mk.2* version of the Avro *Blue Steel* air-to-surface missile. The *Mk.2*, which had reached the mock-up stage, would have had a considerably greater range than the *Mk.1*. *Interavias's* London Correspondent comments that it is regrettable that the *Mk.2* is to be abandoned, as it would have provided essential development knowledge and a stepping-stone to a possible ballistic air-to-surface weapon as reinsurance against delay or cancellation of the United States *Sky Bolt* missile. Preliminary work done by A. V. Roe had proved the feasibility of a ballistic version of the *Blue Steel Mk.2*.

● **The U.S. Air Force** has selected Davis-Monthan AFB (Tucson, Arizona) and McConnell AFB (Wichita, Kansas) as its sixth and seventh bases for operational *Titan* missiles, each base to have two squadrons of ten missiles each. The announcement brings the number of *Titan* squadrons sited by the USAF to ten out of a total of fourteen.

● **Courtland D. Perkins,** Professor and Chairman of the Princeton University Department of Aeronautical Engineering, was sworn in on April 25th as Assistant Secretary of the Air Force for Research and Development.

● **The Royal Australian Air Force** has not yet found the type of replacement it wants for its present *Canberra* light bombers, despite press reports that such types as the Blackburn NA.39, the *Mirage IVA* and even the Vickers/English Electric TSR.2 have been under consideration. The strong support reported earlier for the North American A3J *Vigilante* is believed to have waned owing to the high cost involved.

As regards the choice of a supersonic fighter for the RAAF, the F-104G, the *Mirage III* and the Northrop N-156F are to come under study. It has not yet been revealed whether the selected aircraft will be procured directly from abroad or manufactured under licence in Australia. An RAAF mission, headed by Air Vice-Marshal R. E. Hancock, will shortly be making a more detailed study of the matter.

● **General Thomas S. Power,** Commander of the USAF Strategic Air Command, has announced that converted Boeing KC-135 jet tankers will be available, from July 1st, to operate on continuous airborne alert as flying command posts. The KC-135s are to be modified as miniaturized versions of the SAC Omaha control centre, and will direct SAC retaliatory action in the event that the underground command post is put out of commission by enemy nuclear action.

First picture of the Hustler *production line at the Convair Division of General Dynamics Corporation's plant at Fort Worth, Texas. The aircraft travel through the 4,000-ft long building on raised rails and are lowered to the ground at the end of the assembly line. The 43rd Bomber Wing of the USAF Strategic Air Command is the first to receive B-58* Hustlers.

The two-seat Grumman A2F-1 Intruder *naval strike aircraft, powered by two Pratt & Whitney J52-P-6 jet engines of 8,500 lb thrust each, is designed to operate at high subsonic speeds. The engine jet pipes can be deflected downwards hydraulically to shorten take-off distance. The* Intruder *is fitted with the Digital Integrated Attack Navigation Equipment (DIANE), which enables it to operate in all weathers and at very low altitudes, and to detect targets in the poorest atmospheric conditions. The aircraft can carry both conventional and nuclear weapons.*

The Dassault-Sud Spirale *colonial multi-purpose aircraft, which began flight tests on April 8th. The* Spirale *is powered by two Turboméca* Bastan *propeller turbines.*

General Power said that pending any requirement for the flying command posts to be kept on air alert, at least one of the aircraft would always be on 15-minute ground alert.

● **The Indian Government** has placed an order with Société des Ateliers d'Aviation Louis Breguet for Type 1050 *Alizé* three-seat ASW aircraft to equip the carrier *Vickrant*, which is due to enter service with the Indian Navy in the near future; reports from Paris do not quote the number of aircraft ordered or the value of the contract. Breguet is also producing the *Alizé* to equip the French Navy carriers *Clemenceau* and *Foch*.

AIRCRAFT AND EQUIPMENT

● **A VTOL test aircraft,** designed by Curtiss-Wright and utilizing two new radial lift propellers, has been tested at an altitude of 5,000 ft. At this altitude transition was made to horizontal flight at a speed of 165 m.p.h., and after a 50-mile flight the aircraft landed vertically. Curtiss-Wright is also working on a six-seat model with four of the special propellers.

● **The Bell XV-3 Convertiplane** has so far completed more than 100 hours of flight testing and has made 74 full conversions from vertical to horizontal flight or vice versa.

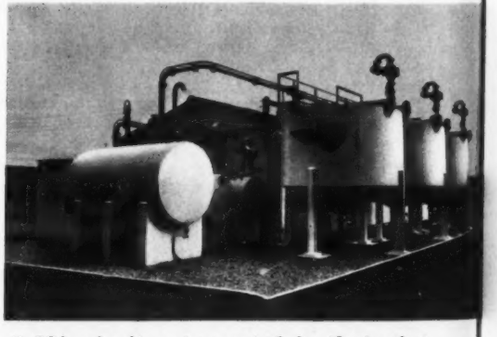
The newly-founded Rotorwing Aircraft Company of Birmingham, Alabama, has completed the gyroplane shown in the picture, which is powered by an 85 h.p. Continental engine and is shortly to begin flight tests. A two-seat production version, the Sportsman, *with a 115 h.p. engine, is to be placed on the market at a later date; price $5,600. Various versions of this two-seater are planned: the* Pelican *for fish-finding, the* Grasshopper *for agricultural work and a military version for anti-tank operations, communications etc.*

● **The Allison-Convair** turboprop conversion of the Convair 340/440 airliner has received FAA certification for commercial service. Three aircraft were used in the FAA flight evaluation programme; these were the YC-131C (military prototype of the Allison-Convair) plus the first two aircraft off the conversion line. Conversion work is being done by PacAero, a subsidiary of Pacific Airmotive Corporation and subcontractor to Allison on the Convair 340/440 programme. The Allison-Convair cruises at 350 m.p.h., block speeds are increased by 25 to 30%, and rate of climb at sea level is approximately 4,000 f.p.m. Certificated maximum take-off weight is 53,200 lb, minimum field length 4,180 ft, and approved maximum landing weight 30,670 lb. Eight aircraft are at present under conversion at PacAero, with a total of 16 sold to date. Customers include Lake Central Airlines, which has ordered five aircraft and taken options on ten more. Eleven more conversions will soon be in service with Allison, A.C. Spark Plug, Ford Motor Company, Union Oil Company, Humble Oil Company, etc.

● **The Dassault Etendard IVM** second and third prototypes (the latter with Rolls-Royce *Avon*) have now completed their catapult take-off tests and simulated deck landing trials at the RAF's Bedford base. A total of 114 catapult take-offs have been made, with and without external loads and at maximum gross weight (auxiliary tanks, bombs and rocket launchers). Both prototypes are equipped with ONERA/SFIM data transmission systems.

● **Scintex Aviation** has brought out a new sports and touring four-seater known as the ML.145 *Rubis*. Flight testing is scheduled to begin in July. The company is also still producing the CP.301 *Emeraude* two-seater, of which 145 have so far been delivered (including 34 for export). Monthly output is at present six aircraft.

● **Siemens-Schuckertwerke AG,** of Berlin and Erlangen, offers a range of new or developed equipment for airport and obstruction lightning purposes. The AHF 27-1 high-intensity approach light has a 24 V/200 W lamp for lateral illumination and a 40 V/40 W lamp for vertical radiation. Special attention has been given to light weight and low height. This model can



Air BP has placed in service a new jet fuel purification plant (filtering, water elimination) at the Flight Refuelling Limited Tarrant Rushton airfield near Blandford.

also be used as a threshold light, like the older SHF 20d-1 (light-metal casting, two 24V/200W lamps and one 40V/40W, maximum intensity more than 400,000 cd). Another new model is the SHF 17d-1/u high-intensity runway light of cast light metal, with a 24V/100W lamp on either side and a 40V/40W lamp on top. It can be operated with either sealed-beam lamps or normal lamps plus reflector. For airfields without ILS and in particular for helicopter operations, there is the AWF 5 approach light, which can be either fixed or portable. Three coloured segments (yellow, red and green) flash consecutively by means of a motor-driven shutter, thus providing optical indication of the glide slope. Other new items include the AF 17 L approach light (24V/100W lamps), the SF 13 L runway light with a 24V/100W lamp at the common focal point of two reflectors, and the RF 12 L taxiway light with blue omni-directional lens (12V/55W). Finally, a high-intensity rotating light is being developed for obstruction marking (e.g., the Stuttgart television tower and the Dortmund telecommunications tower). This works with two special lenses 700 mm in diameter and a 2 kW xenon lamp (Osram XBO 2001).

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The DRAKEN 35B — with a more powerful Rolls Royce engine and other improvements — has a top speed of Mach 2+ and an initial climb rate of 50,000 ft. per minute. The Draken 35B is equipped with advanced collision-course fire control and can alternatively carry rocket and guided missile fighter armament or heavy attack armament — rockets or bombs.

The DRAKEN has full radar and navigation equipment for all-weather operation. Excellent handling qualities at low speed allow using even small shut-in airfields.

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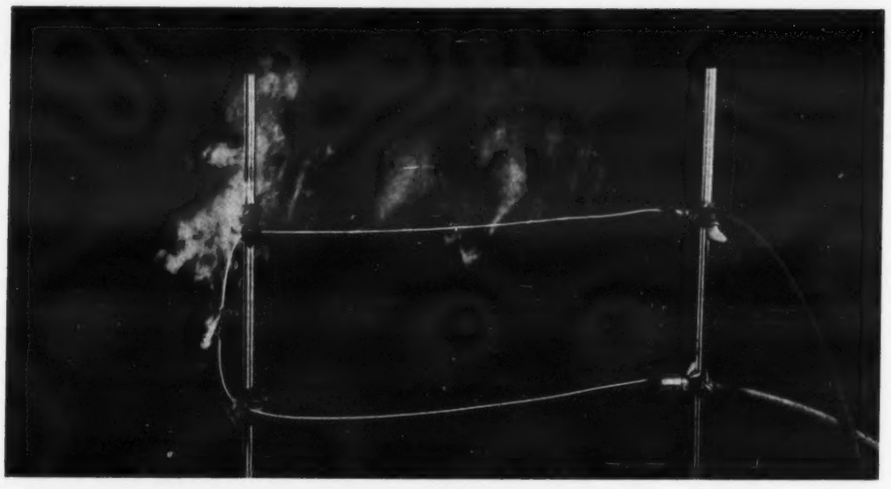
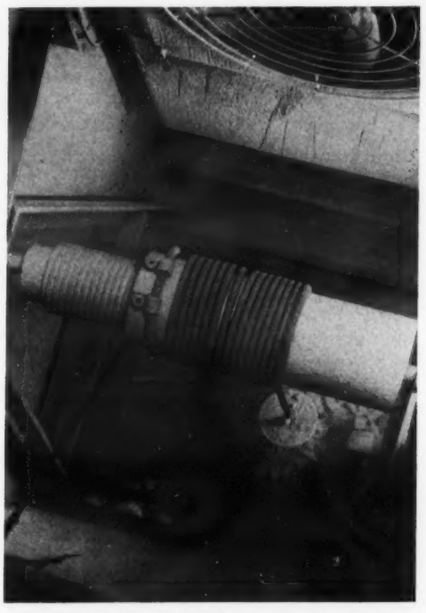


TEMPORARY OVERLOADING can lead to possible insulation damage or degradation. The ability of an insulation to withstand a sudden surge of current is a major consideration in the selection of wiring materials. Here a new silicone-rubber formulation effectively withstands a 700 per cent temporary overload which has caused a normal PVC insulation to burst into flames.



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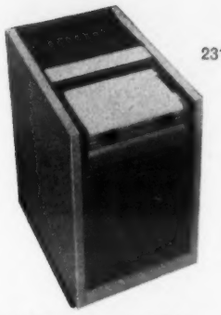
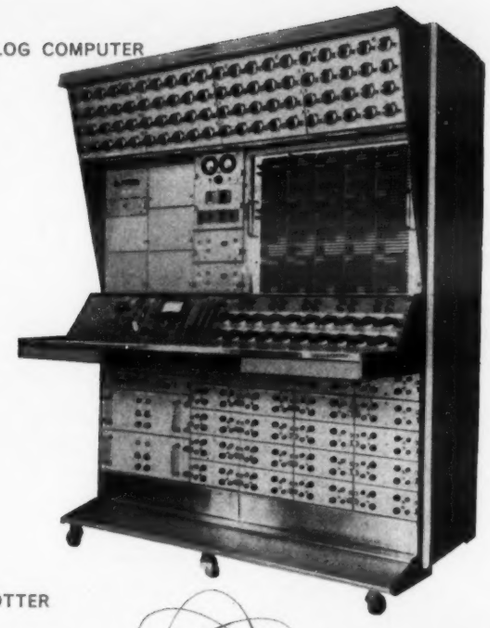
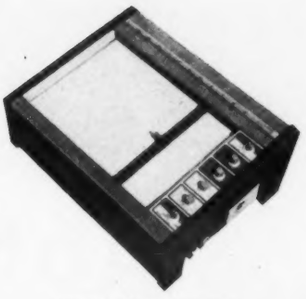


231 R ANALOG COMPUTER





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8 CHANNEL RECTILINEAR RECORDER

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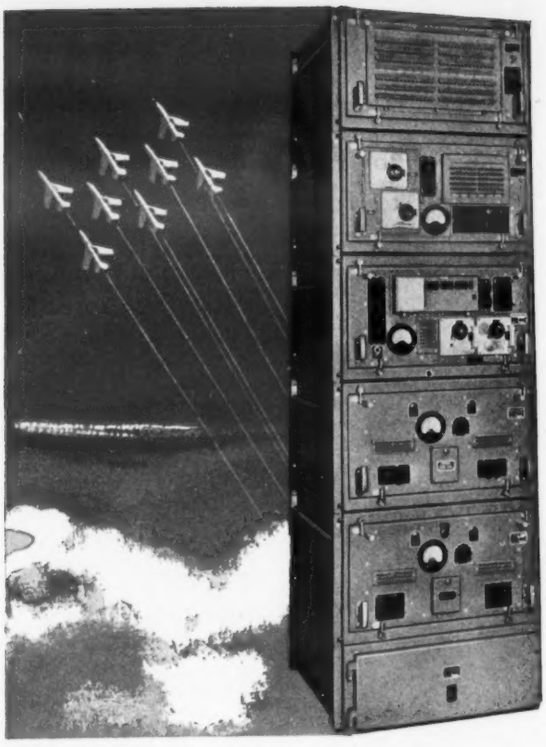

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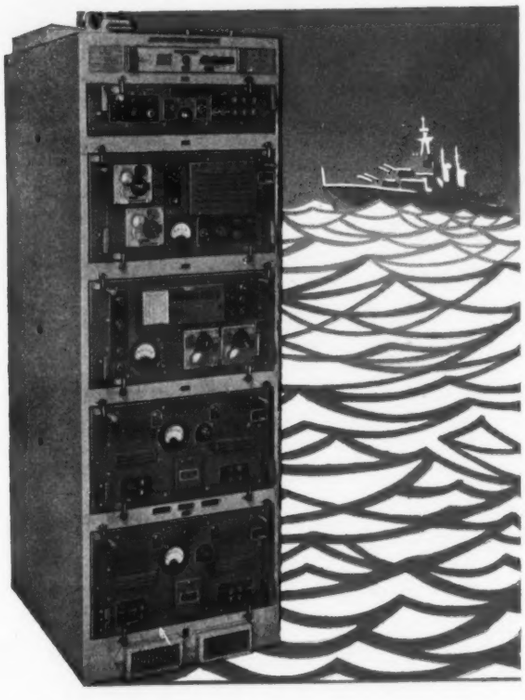

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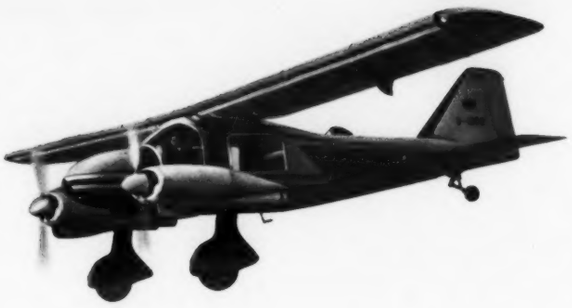
The 1960 German Air Show



This year the sun was on strike . . . and the north wind blew leaden-grey clouds low over Hanover-Langenhagen Airport as Federal Minister of Economics Professor Erhard opened the 1960 German Air Show on April 23rd. A small cloud also appeared over the opening ceremony when Professor Erhard, replying to the suggestion by Dr. L. S. Rothe, Chairman of the Federal Association of the German Aircraft Industry, that support should be given for civil aircraft production, pronounced these words: "Before embarking on production (of civil aircraft) or even continuing research and development work, there should at least be some market research, which should not be limited to Germany. Market prospects throughout the world should be studied . . . You all know that I am fundamentally opposed to subsidies, and in fact to any excess State intervention in the economy."

A first tour of the exhibition left no doubt that the programmes of the major German aircraft and equipment companies are tailored primarily to military requirements and that there is a long way to go before they can undertake quantity production of commercial aircraft of any kind. At the same time the Show almost made one forget that it is only five years since the Federal German Republic, after ten years of enforced idleness, began to build up its aircraft industry again.

This is the third year that the Federal Association of the German Aircraft Industry has organized, in conjunction with the Deutsche Messe- und Ausstellungs AG (which runs the Hanover Trade Fair), the air show which has now become an annual event. The exhibition grounds have been considerably enlarged, and this year the organizers were able to assemble no fewer than 172 companies—compared with 107 in 1959 and only 57 in 1958. The more than 90 West German exhibitors at Langenhagen proved conclusively that the German aircraft industry has now regained its rightful place among the other European industries. The participation of eighty well-known companies from France, Britain, Italy, Austria, Switzerland and the United States gave the Show an international cachet and mirrored the growing importance of Germany as a customer for aeronautical equipment of all kinds. Undoubtedly one of the reasons why Britain and France, for example, made a big showing with their stands presenting an overall survey of national products, can be found in the efforts which the authorities of these two countries are making to organize joint European aeronautical development, at any rate where military requirements are concerned. The visit by Federal Defence Minister Strauss and Britain's Aviation Minister Duncan Sandys on the opening day underlined this trend. But some day civil production programmes will also have to extend beyond national frontiers. The economic organization of Europe will make this inevitable.

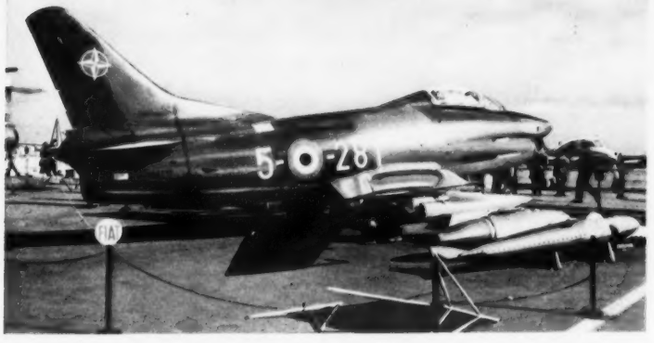
*

With the exception of sports and touring aircraft, the catalogue of German exhibitors was still dominated by licence production for the Air Force: the *Magister* jet trainer, P.149D piston-engine trainer and the *Noratlas* transport. Every corner of the exhibition building revealed signs of the plans for quantity production of the F-104G and G.91 single-seat jet combat aircraft, and even the C.160 *Transall* assault transport project left its visiting card at several French and German stands.

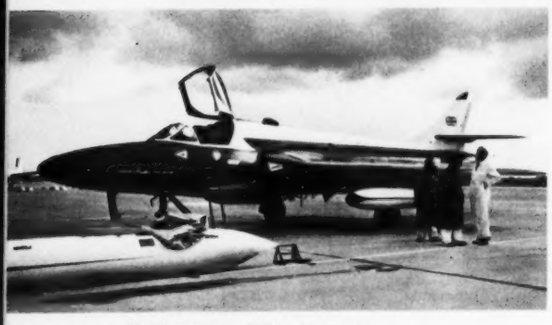
Finally, the Air Show also revealed the efforts now being made by the German equipment industry to get into the aviation business. Aside from original designs of such electronics companies as Telefunken and Standard Elektrik Lorenz for the civil market, these efforts are admittedly still confined to the licence manufacture of foreign equipment for the above-mentioned military projects. But manufacturers are already trying to improve on foreign products and—with an eye to further military contracts—to develop some of their own ideas. The German supply industry for structural materials, semi-finished metal parts, plastics, mouldings and castings, tools and jigs has long obtained a secure foothold in the international market. The majority of the 270 "companies with aeronautical interests" exhibiting at the main Trade Fair at Hanover-Laatzen fell into this category. Never before at a German exhibition has so wide a range of aeronautical equipment been seen, from electrical and electronic airborne systems via pneumatic and hydraulic equipment to recovery devices, test apparatus and airport equipment, led by a proud offering of radar equipment for the most varied navigation and traffic control requirements.

As regards new aircraft designs, the German aircraft industry had only few models to show this year—the scope for initiative in the civil sector is, of course, limited. In addition to the Dornier Do 27 originally shown in 1958, the Munich company made a first demonstration of the Do 28 six-seat STOL touring aircraft with two 250 h.p. Lycoming engines, the standard version of which is being offered at a price of DM 196,000. Apparatebau GmbH (subsidiary of Bölkow-Entwicklungen KG) brought several versions of its Klemm Kl 107 sports and touring aircraft (150 h.p. Lycoming engine) to Hanover, and Rhein-Flugzeugbau GmbH came with details of the RF 1 twin-engine STOL aircraft with ducted fan, central semi-annular wing and jet deflection. Siebel unveiled the SIAT 222 four-seat sports and touring aircraft, the prototype of which is now nearing completion. Equipped with a 180 h.p. engine and v.p. propeller, this all-metal low-wing monoplane is designed for a top speed of 200 m.p.h. With this new aircraft Siebelwerke-ATG hopes to continue the tradition of its internationally-known pre-war Si 202 *Hummel* two-seat sports model. The company stresses that the SIAT 222 is in every way up to present-day standards as regards

The German Air Show premises at Hanover-Langenhagen, showing the new concrete apron in front of the exhibition building.



The Lockheed F-104 single-seat jet combat aircraft (left) and the G.91R photographic reconnaissance version of the G.91 strike fighter, both of which are to be built under licence in Germany, were demonstrated in flight each day.



Hawker *Hunter T.7* jet two-seater.

Armstrong Whitworth *Argosy*.

This Nord 1110 with Turboméca *Astazou* propeller turbine was exhibited by SFERMA.

design, comfort and equipment. The firm of Pützer exhibited the *Elster B*, Rhein-Flugzeugbau GmbH the RW 3 *Multoplane*, Stark Flugzeugbau KG the *Turbulent D*, Focke-Wulf the Piaggio/FW P.149D, and Apparatebau Nabern GmbH the Fauvel AV.36CM powered glider and the FS24 *Phönix* high-performance sailplane (sandwich construction of fibreglass-reinforced plastic and balsa wood).

Typical among the foreign sports and touring aircraft on show were the following: CP.301C *Emeraude*, Beechcraft 33 *Debonair*, Beechcraft 95 *Travel Air* and Beechcraft 65 *Queen Air*, Cessna 210 and 310C, Piper PA.24 *Comanche*, the twin-engine Simmering-Graz-Pauker M222, the Aeromere F.8.L. *Falco*, *Aero Commander*, Wassmer *Super IV* and several new designs from Société Aéronautique Normande (Jodel). Multi-purpose transports present were—besides the Do 27 and Do 28—the Pilatus PC.6 *Porter* and the Lancashire Aircraft *Prospector*, while the Piaggio P.166 high-speed eight-seat touring aircraft was shown in the three-seat photographic version for Hansa Luftbild GmbH.

The demonstration of approaching 50 small aircraft types from throughout the world undoubtedly made the 1960 German Air Show the most interesting exhibition of sports and business aircraft ever held in Europe. One practice at Hanover that would merit imitation elsewhere: anybody interested could at any time make a flight in any of the aircraft. This emphasized the basically civil aims of the Show as a true sales fair.

Above all Cessna left no doubt that it is seeking to widen its market in Europe. The company's agreement with Max Holste for the licence production of Cessna aircraft in France suggests confidence in the prospects. Beech Aircraft Corporation has handed over a *Twin Bonanza* and a *Travel Air* to SFERMA for conversion to propeller turbines (Turboméca *Bastan* and Astazou respectively), and the same French company fitted a Beech 18 some time ago with the *Bastan* turboprop; it now remains to be seen how far the twin-turboprop business aircraft in this weight class arouses world-wide interest. A Nord 1110 equipped by SFERMA with an *Astazou* propeller turbine was demonstrated at Hanover by General Ladousse, attracting considerable interest. The engine's automatic governor with automatic propeller pitch control and automatic fuel flow control to meet thrust requirement (both with constant engine and propeller r.p.m.) showed that the propeller turbine's potential for smaller sports and touring aircraft is by no means exhausted. A Do 27 is also shortly to be equipped with this well-known Turboméca turboprop.

British exhibits included two *Prospectors*, the two-seat Hawker *Hunter T.7* and—also demonstrated by the Hawker Siddeley Group—the Armstrong Whitworth *Argosy*. The Vickers *Vanguard* also put in an appearance on April 28th and took representatives of the press, radio and television on a number of flights, thus providing one more sign of the importance which foreign exhibitors attach to the German Air Show. Almost every day a Lufthansa Boeing 707 appeared over the airport, discreetly recalling, with the whistle of its Rolls-Royce jets, that the German aircraft industry now also has to embark on the maintenance and overhaul of the biggest jet aircraft.

Sikorsky S-62, Agusta-Bell 47G and 47J *Super Ranger* and Sud-Aviation *Alouette II* helicopters took off untiringly from the special helicopter area, while the Bölkow *Heli-Trainer*—firmly anchored to the ground—was used to acquaint visitors with the flying and control qualities of a real helicopter.

*

The engine sector was still dominated by the foreign exhibitors, which included Bristol Siddeley, Napier, Rolls-Royce, SNECMA and Turboméca. BMW Triebwerkbau GmbH presented the

Apparatebau Nabern GmbH showed four Klemm Kl 107Cs.

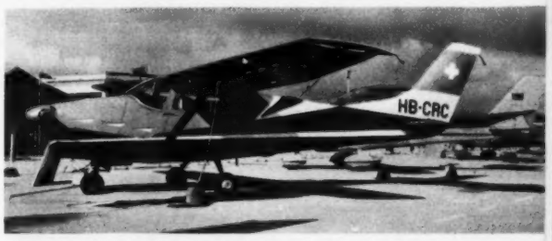
Do 27 (right) and Do 28, two six-seat short take-off multi-purpose aircraft with Lycoming engines.

first post-war German design, the Type 8025 small jet (auxiliary power unit for sailplanes) and showed a cutaway model of the General Electric J79 jet which the company is to build under licence. MAN and Daimler-Benz have not yet exhibited at Hanover-Langenhagen. Bristol Siddeley's picture of the BS-75 ducted fan engine drew attention to a new category of powerplant which can be expected to find a field of application in short-haul aircraft of the Hunting 107 class and in STOL transports. If one of the leading British engine manufacturers has seriously embarked on the development of a ducted fan model in the 6,500 to 8,500 lb thrust class, this can only mean that it is confident there will be a worthwhile market for subsonic engines for a good many years to come. The BS-75 has an unusually high by-pass ratio and is reported to deliver a thrust of 7,000 lb in the first development phase. The Lycoming Division of Avco Manufacturing Corporation presented its T53 gas turbine in the outdoor show; this is recommended as powerplant for a helicopter to be ordered by the Bundeswehr.

pation is that the whole programme might be cancelled, and even before any such large-scale production project can come into being the manufacturers of military airframes and equipment must get out onto the road, in order to convince the main contractors of the qualities of their products and secure for themselves a rewarding share of orders. Ultimately, of course, all must accept the authorities' decisions, which are not always free of political motives. In view of these various hazards, national companies are forced into increasingly close collaboration, or even mergers, and must be prepared to accept a greater measure of international cooperation. The Air Show at Hanover-Langenhagen proved this in many respects.

The French industry, which rented some 5,400 sq. ft. of exhibition space and was represented by more than 40 companies, is making particular efforts to achieve closer cooperation with the German industry. France is a close neighbour, similar working and manufacturing methods are used in the two countries and both utilize the

Pilatus PC.6 *Porter* multi-purpose aircraft with 340 h.p. Lycoming supercharged engine.



Cessna 210 touring and business aircraft (260 h.p. Continental injection engine).

Beechcraft 65 *Queen Air* executive aircraft (two 340 h.p. Lycoming engines).

The prototype of the Siebelwerke-ATG SIAT 222 touring and sports four-seater (180 h.p. Lycoming engine) will shortly be completed.

Simmering-Graz-Pauker M 222 touring four-seater (two 150 h.p. Lycoming engines).

While sales of sports and touring aircraft still depend primarily on real selling efforts . . . and a certain amount of luck—the manufacturers and agents represented at Hanover were constantly chasing potential customers—the 1960 Air Show revealed the growing tendency on the military side towards far-reaching long-term production agreements involving several groups of companies —agreements which can eventually be expected to acquire international status. Within these giant programmes the manufacturers' sales problems are quite different ones. Their constant preoccupation metric system, and finally the two governments are striving for military and technical coordination; all this should encourage closer ties. A promising beginning has been made with the licence production of *Noratlas* and *Magister* and the procurement of a substantial number of *Alouette* helicopters and of SS.10 and SS.11 anti-tank missiles; this is now to be followed by joint manufacture of the *Transall* assault transport and the *Atlantic* naval patrol aircraft (the latter in cooperation with other European countries). Companies such as Air Equipement, CSF, Messier, SFENA, SFIM and Thomson-Houston will for years to come plan their production programmes with an eye to the needs of German customers and of all other potential purchasers within the NATO market. The same of course applies to such British firms as Cossor, Decca, Dowty, Marconi, Normalair, Sperry, Standard Telephones and Cables, etc., particularly as there are signs that Britain, France and Germany may well go hand in hand in the development of the VTOL combat aircraft requested by NATO. British engines are already powering a good number of continental

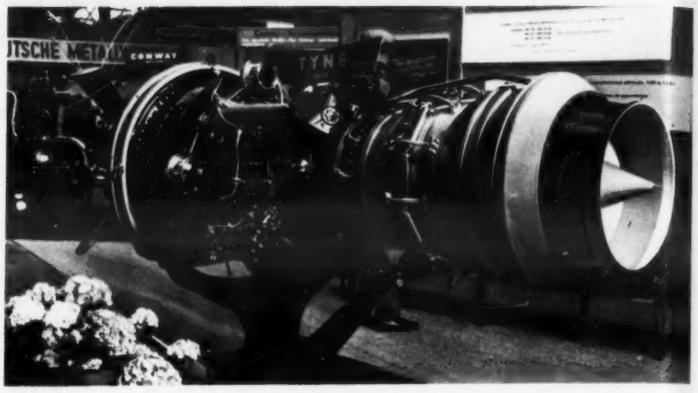
Federal Economics Minister Professor Ludwig Erhard and Colonel F. Wirth, French Air Attaché to Bonn.

Defence Minister Franz Josef Strauss and Nord-Aviation President P. Mazer inspect a model of the new Dassault *Mirage IIIE* photographic reconnaissance aircraft.

The fastest man at the Hanover Show, F-104 pilot Captain Skelton of the USAF, is initiated into the secrets of slow flight by Captain Heinrich Schäfer in the Do 27.

Opening tour. Front row, left to right: Dr. L. S. Rothe (Chairman of the German Aircraft Industry Association), Britain's Aviation Minister Duncan Sandys, Federal Defence Minister Franz Josef Strauss, Dr. Th. Benecke, Head of the Air Force Technical Section, Federal Defence Ministry, and Director Pätzold of the Deutsche Messe- and Ausstellungs AG.

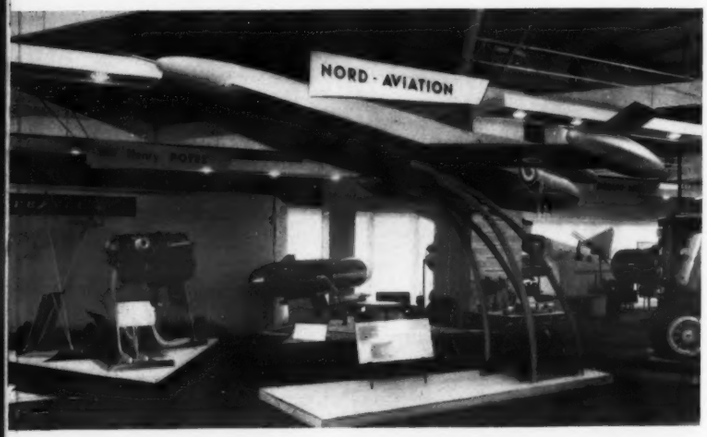
The Bristol Siddeley stand. The picture on the rear wall is of the BS-75.



Rolls-Royce's exhibits included the *Tyne* propeller turbine, powerplant for the Franco-German *Transall* assault transport and the Breguet 1150 *Atlantic*, NATO's naval patrol aircraft.

Hughes International's stand provided information on a number of interesting new developments in the electronic field. In the foreground, the Frescanar radar, in the rear a control desk for the fire control equipment of the MSG4 weapons system.

Messier showed its four-wheel main undercarriage for the Dassault *Mirage IV* supersonic bomber.



Nord-Aviation's offering included a full-scale CT.20 target drone and the *Sirius* ramjet (rear left), while SEPR contributed the 706 and 734 solid-propellant rocket motors for the Matra 422 anti-aircraft missile.

The French aircraft industry's joint stand, where Sud-Aviation showed several models of the *Caravelle*, Potez a number of aircraft engines and a model of the Potez 840 (rear right), Dassault a first model of the *Mirage IIIE* photographic reconnaissance aircraft and an impressive assortment of external loads.

Aviation Electronics at Hanover

Unlike other countries, whose electronics industries have for years enjoyed government backing for their aviation products and have been able to develop over a broad range, Germany has so far had to rely on independent civil projects developed by a few large concerns.

For some time Standard Elektrik Lorenz has been producing a VOR rotating beacon to meet ICAO requirements for short-distance navigation. The firm brought to Hanover a VOR/FLEX ground installation and a VOR/ILS airborne system. A new development was a remote radar retransmission system using a condenser to compress radar signal bandwidth, enabling radar information to be stored for transmission when required. Telefunken presented a new type of precision approach radar in a fixed (PAR-3) and a mobile (PAR-C) version, together with a medium-range radar, three of which are being installed for the German air traffic control authorities. Another completely new development is the Plath optical direction finder, on show for the first time at Hanover. Siemens & Halske showed pictures of its desks for air traffic control centres and control towers; this equipment has been delivered to many authorities abroad and, more recently, to the German air traffic control authorities. In addition, mention should be made of the AEG and Siemens flashing approach lights. Also on show was the Assmann multi-track magnetic recording equipment, which has been in use for many years both in Germany and abroad; both the proven 24-channel equipment and the new, largely transistorized 12-channel equipment were on show.

German licence manufacture of foreign products has so far been limited to TACAN ground and airborne equipment (Standard Elektrik Lorenz/LMT), radio altimeters (Standard Elektrik Lorenz/ Standard Telephones and Cables) and a few radar equipments (Telefunken/Bendix).

Foreign firms had much to offer: Bendix International and Collins exhibited radio and navigation equipment and flight monitoring and autopilot systems. GPL, represented by Eichweber, displayed the RADAN 500/TNC-50 doppler radar, already proven in operation. Detailed information was given on the semi-automatic air traffic control system developed by GPL for the U.S. Federal Aviation Agency, which is at present undergoing tests. Hughes International showed an interesting selection from the Hughes Aircraft production range: the MSG-4 *Missile Monitor*, mobile air defence system (with three-dimensional Frescanar radar) for the ground forces; the TARAN radar navigation and fire control system for single-seat combat aircraft; the *Vocoder* long-range telecommunications system for converting voice signals into digital symbols; various new types of cathode ray tubes, including the Memotron, Typotron and Tomotron.

The British electronics industry, too, was represented in strength at Hanover. Cossor showed a model of a mobile surveillance radar equipment for military early warning and air traffic control, and the well-known Mk.10 ATC transponder; Marconi exhibited navigation aids, including doppler radar, and a fully transistorized airborne teleprinter receiver, so far the only equipment of its kind. Marconi, which, like most of the British firms at the exhibition, was represented by Kirchfeld KG, could present only a fraction of its comprehensive radar programme.

Telefunken, as German representative of Decca, exhibited the latest Decca airborne equipment. VDO, representing the Smiths Group, displayed an automatic blind landing system developed in Britain by the following firms: Pye (ILS with an exceptionally precise beam for the approach path); Murphy Radio (magnetic leader cable system); Standard Telephones and Cables (whose radio altimeter is also manufactured by Standard Elektrik Lorenz); and Smiths (autopilot, automatic throttle control and monitoring instruments).

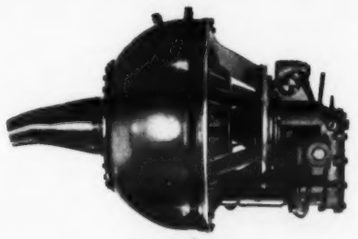
The French electronic industry's contribution consisted of flight monitoring and communications equipment, and radar installations. Of particular interest was the CSF system for the remote transmission and display of radar information using television techniques, for which a new converter tube has been developed. CSF attaches great importance to electronic tubes, and released certain details of some of its new products in this field (such as the Carcinotron) for the first time at Hanover. Thomson-Houston exhibited, in addition to individual equipment units and special tubes, a model of the *Lynx* experimental radar station for the detection of mines at sea.

The Hanover Air Show furnished yet another irrefutable demonstration of the extent to which modern flight operations depend on the quality and reliability of electronic aids. On April 30th Hanover-Langenhagen Airport recorded 1,154 take-offs and landings, without regular scheduled services being in any way affected.

Joint stand occupied by Weser Flugzeugbau GmbH and United Aircraft Corporation. Front left, a model of the JTD 3F turbofan jet, centre a cutaway model of the JT12 jet, right models of the Sikorsky S-61B, Weserflug/Sikorsky WF/S-61C and Weserflug/Sikorsky WF/S-64.

European military aircraft types and are also projected for tomorrow's European military models (G.91, *Transall, Atlantic,* etc.).

Finally, not only European but also American companies are seeking closer ties with the German aircraft industry, as is revealed by the presence at Hanover of companies such as Collins, Bendix, General Precision Laboratory, Hughes Aircraft and United Aircraft. A typical example of the association between large American undertakings and European companies was furnished by the joint stand occupied by United Aircraft Corporation and Weser Flugzeugbau GmbH. On show here were the Weserflug/Sikorsky WF/S-64 crane helicopter and the WF/S-61C assault transport helicopter with large rear loading door (both powered by the turboprop version of the Pratt & Whitney JT12), which have been put on the short list within the framework of the German helicopter procurement programme. Also on show was a model of the *Transall* transport, a joint development by Weser Flugzeugbau, Hamburger Flugzeugbau and Nord-Aviation. It is to have two Rolls-Royce *Tyne* propeller turbines and in all probability two Pratt & Whitney JT12 auxiliary jets; the latter would be built by SNECMA under an agreement between Pratt & Whitney and the French company. In addition United Aircraft exhibited on the joint stand a model of the JTF3D turbofan jet, which is being offered in Europe as powerplant for VTOL aircraft and is—reportedly—used in a Weser study project.



BMW 8025 small jet for use as auxiliary power unit for sailplanes.

Cine-theodolite manufactured by Bodenseewerk Perkin-Elmer & Co., with separate control unit.

Strüver GmbH presented an interesting cross-section of its production programme. Left, from front to rear, self-propelled power supply unit for jet aircraft (75 kVA), "Rollstarter" engine starter unit (800/1,500 amp., 27.5 volts) and compressor unit with 280 h.p. diesel engine for starting jet engines.

Summing up

Apart from the target drones and anti-tank weapons on the Nord-Aviation stand, missiles were not included in the German Air Show, since it was originally designed to be a civil exhibition. Bodenseewerk Perkin-Elmer did, it is true, show some guided missile test and measuring equipment, but without any reference to the European *Sidewinder* programme of which the company is the coordinator. In future years, however, rockets too should become a part of the exhibition picture.

The organizers of the show at Langenhagen are to be congratulated, and it is to be hoped that, despite the increasing signs of concentration in the European aviation industry, the number of exhibitors will grow from year to year. Finally, it cannot but be emphasized that the Hanover Air Show has shown some highly rewarding results. Over 100,000 visitors from all over the world, including countless international observers, ambassadors, air attachés and representatives of governments as far away as Asia and Africa; the sale of 50 sports and touring aircraft during the period of the Show alone; and the establishment of promising business connections. D. Napier and Son Ltd. booked a substantial order: all the Lockheed F-104G single-seat combat aircraft to be built in Europe, as well as the *Transall* military transport, will be fitted with the Napier Spraymat de-icing system. The value of the German contract alone runs to £1.5 million. Incidentally, the charter company Deutsche Taxiflug GmbH, which today serves over a score of airfields in Germany and runs a small fleet of Do 27s (shortly to be supplemented by Do 28s), did a roaring trade with its rapid connection between Hanover-Langenhagen Airport and the grass strip in front of the entry to the main body of the Hanover Fair at Laatzen.

Sky Swing tip-up passenger seat and a model of the HFB 314 jet aircraft on the stand of Hamburger Flugzeugbau GmbH.

The German Federal authorities will no doubt be surprised to hear of the resounding success which the Hanover Air Show has had abroad, and perhaps they may again ask themselves whether they should in future do still more to support the young German aircraft industry. Admittedly, individual manufacturers cannot think of immediately entering the whole field of aircraft production in which the industries of other countries throughout the world are engaged. If, however, things ever got to the state where the technological gap between the German industry and those of other countries grew larger instead of smaller, the firms of the Federal Republic would start with a distinct handicap as partners in a common European aircraft industry. ⟶

Electronics in Aviation and Industry

What's New in Electronics?

● **Hoffman Electronics Corp., Los Angeles, Calif.** has recently introduced three new semiconductor products. These are silicon tunnel diodes, 50 watt silicon Zener power regulators and the silicon photovoltaic detector capsules illustrated here. Primary applications of these units are in light detection, infrared sensing, counting devices and in reading punched cards.

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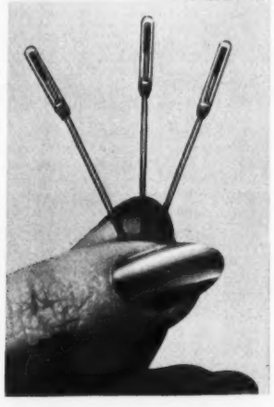

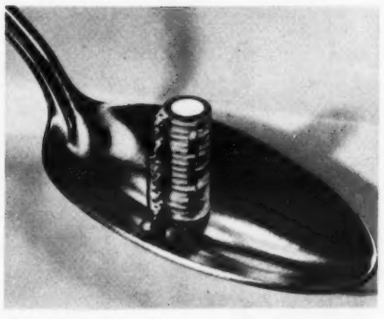

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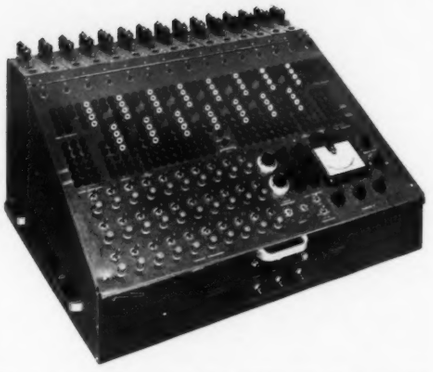
● **General Electric Company, Owensboro, Ky.** has developed this new device known as TIMM (Thermionic Integrated Micro-Module), a half-inch ceramic cylinder containing a complete electronic circuit. The metal and ceramic encapsulated components are thermally insulated to retain the heat generated in operation, making the built-in tubes self-heating. To illustrate the component density which can be achieved with the micro-miniature components, the company has built a 100 tube digital computer the size of a cigarette packet.

● **Edo Corporation, Long Island, N.Y.** has produced the Model 345A Loran receiver which is sufficiently compact to be fitted in medium sized aircraft. The installation shown here is fitted on board the company's twin-engine Cessna 310. The directly-read control unit and display scope are mounted between the pilot and co-pilot seats while the receiver unit fits a ¾ ATR rack in the electronics compartment. The unit has automatic frequency control, which eliminates signal drift and the pulse positioning is carried out by adjustment of the delay controls at the bottom of the control panel. The total microsecond delay between reception of the signals is then read directly from the numerals on the control knobs.

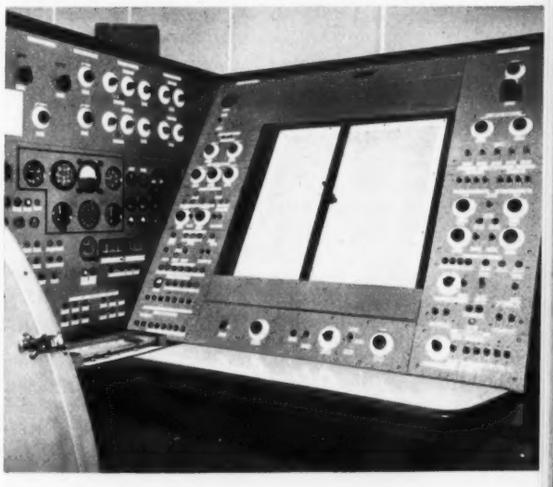
● **The 1960 International Convention** of the Institute of Radio Engineers was held on March 21st—24th in the New York Coliseum and the Waldorf-Astoria Hotel. At the convention's Radio Engineering Show some 25,000 different items of electronic apparatus were displayed; ranging in size from microminiature components to large computing machines. This was the largest technical exhibition ever staged in the United States, and displayed the latest technical developments of 865 electronics firms. Of this total, New Jersey, sometimes referred to as the Electronics State, was represented by a total of 128 separate companies, including such names as Bendix Aviation, Cornell-Dubilier Electric Corporation, Allan B. DuMont Laboratories, Inc., International Telephone and Telegraph Company, Radio Corporation of America, Radio Frequency Laboratories, Sylvania Electric Products Inc., and Tung-Sol Electric Inc.

For the 65,000 engineers and scientists who came from forty countries to take part in this international convention, the visit represented four crowded days. Apart from the physical effort of trying to see 2½ miles of exhibits, fifty four technical sessions were held, during which 270 papers were read. The topics ranged from communication satellites to domestic sound entertainment. After the Convention the delegates may well have been able to add their personal comments to those of H. I. Romnes, President of Western Electric Company, who, as principal speaker at the annual IRE banquet, chose as his theme, "The Flood Tide in Electronics."



● **Heath Company, Benton Harbor, Mich.** a pioneer and today the world's largest manufacturer of electronic equipment in kit form, has reduced computer electronics to "do-it-yourself" standards. The hardware illustrated above forms the Heathkit EC-1 Educational Electronic Analog Computer which has been designed for assembly by students. The kit fulfils the twofold purpose of teaching computer construction techniques, while the completed instrument can be used for teaching analog computer applications. The completed computer is shown on the right.

◀ ● **Hughes Aircraft Company, Culver City, Calif.** recently demonstrated the MA-1 navigation and fire control system on board an F-106 Delta Dart. Piloted by Major Frank Forsyth, the Air Materiel Command's Chief Acceptance Pilot, the F-106 took off from Palmdale (Calif). After take-off the pilot relinquished the controls and upon receipt of an electronic signal the aircraft, fitted with external fuel tanks, then flew on a pre-programmed flight plan to Jacksonville, Fla. a distance of 2,500 miles. Working on information supplied by TACAN stations across the country, the Hughes MA-1 system automatically compared the aircraft position to the prescribed route and supplied the navigational corrections. The system electronics installation is illustrated here.



● **General Precision Systems Ltd., Aylesbury, England,** formerly Air Trainers Link Ltd., has been engaged for a number of years on the design and construction of flight simulators and other synthetic training aids for both civil and military users. Between 1950 and 1960 the company has supplied over 30 electronic flight simulators for such aircraft as the *Comet Mk. 4*, the *Vanguard* and the Boeing 707-048. The illustration shows the instructor's console of a *Scimitar* simulator built for the Royal Navy. The complete installation is mounted in a trailer and is fully mobile. The unit can then be transported to any Naval airfield where *Scimitar* conversion training is being carried out. ▶

◀ ● **Royston Instruments Ltd., Byfleet, England,** has supplied MIDAS magnetic data recording equipment to measure vibration levels in the Short SC.1 VTOL aircraft. The picture shows the equipment being installed in the aircraft at the RAE Bedford where vibration trials during transition flights are taking place. Recordings are taken from thirty vibration pick-up points throughout the aircraft, six channels being recorded simultaneously.

● **Martin Company, Baltimore, Md.,** displayed this gyroscopic Far Infrared Scanner for the first time at the IRE convention, New York. Although infrared detection has been concentrated until recently on sensing objects at relatively high temperatures, the new device permits detection of objects having very low temperatures such as a satellite's outer skin surface. All the components of the scanner can be rotated as an integral unit. This creates a gyroscopic effect which would permit the device to remain stable during the spins and turns of a rocket vehicle in which the scanner may be carried. Its range of applications extends from anti-missile missile development to space navigation. Using the infrared radiation emanating from the stars, planets or satellites, it could serve as an aid in guiding a space rocket to its destination. ▶

Photo-Reconnaissance by Radio

A system capable of transmitting pictorial information at high speed over long distances obviously offers a broad range of potential applications. Its employment can be visualized in both the civil and military fields: in industry, research and in space probe experiments. Such a system has been developed by CBS Laboratories, Stamford, Conn., under the name of PHOTOSCAN, and its first application has been in a military role as the heart of a photo reconnaissance system, at present classified. While undergoing comprehensive trials, it has satisfied the most exacting military requirements in speed of transmission, definition and clarity of image.

When applied to reconnaissance, the value and capability of an image transmission system becomes apparent. Success no longer depends upon the safe return of the reconnaissance aircraft, as the data are transmitted almost instantaneously from the search area for evaluation. Furthermore the PHOTOSCAN airborne unit is fully automatic and can be installed in a drone aircraft, and the whole mission carried out without the need for a human pilot. These qualities of high speed transmission together with automatic operation and remote control give some indication of the variety of tasks that the system can carry out.

The Photoscan System

To describe the functioning of the system it is convenient to consider the layout of the aerial reconnaissance equipment. Here the essential elements consist of the Airborne Scanner and the Ground Receiving Equipment. The sensor is an aerial camera mounted on a stable platform. From the camera the exposed photographic film is transported to an automatic, rapid, film developing unit which processes the film in a matter of seconds, and thence to a temporary storage unit which retains the film pending the transmission of the image.

The complex process of converting the film image into video signals for transmission to the ground station is carried out by means of a special scanner. Two of these scanners, or "reader-writer" units, are contained in the system, one in the airborne equipment and one in the ground receiving equipment. These two components are the heart of the PHOTOSCAN system. Known as *Line Scan Tubes*, they are basically cathode ray tubes containing a motor-driven rotating anode. The electron beam generated by the electron gun of the Line Scan Tube continuously scans a line on the rotating phosphor-coated anode drum. This produces a luminous line which is focused on the film by means of a moving lens, resulting in a rapidly travelling spot of light on the film of the size required to ensure the necessary definition.

The linear motion of the light spot on the phosphor-coated drum, the motion of the lens, and the movement of the film transport advance are all synchronized so as to ensure that the film is scanned within a specified time interval. The light from the travelling spot passes through the film and is modulated by the density of the film image. On the opposite side of the film a photomultiplier tube receives the modulated light trace and converts it into video signals.

In the circuit stages after the photomultiplier tube, standard electronic techniques are employed to handle the video signals. After amplification, synchronizing signals are added, and a gain control automatically compensates for any variations in film exposure across any single frame by keeping the average signal level constant. The video signal then modulates a radio transmitter and is emitted for reception by the ground station.

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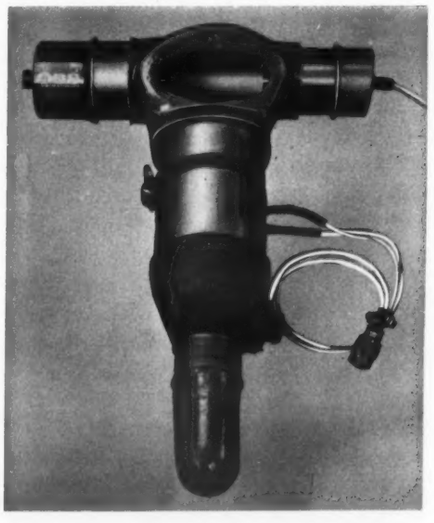
While size and weight considerations necessitate the use of simplified techniques in the airborne unit, these factors do not apply to the same extent in the design of the ground receiving equipment. Here more complicated techniques can be employed in the reconstitution of the transmitted image. Circuitry designed to enhance and "sharpen" the incoming signals is employed to improve the quality and definition of the picture.

At the ground station the signal is received and processed. The video signal is amplified, and the synchronization signal separated. The former then passes to the second of the two Line Scan Tubes contained in the PHOTOSCAN system. In the ground receiver, the Line Scan Tube performs a reverse function to that in the airborne equipment. Here the video signals are employed to modulate the electron beam current of the tube. At the same time the synchronizing signals control the movement of the resultant light spot and also the motion of the moving lens. These movements closely approximate the corresponding motions taking place in the scanning equipment of the transmitter. By using suitable optical magnification it is possible to obtain a change of scale so that it is not necessary to record the image on the same size film as that used in the transmitting equipment. The intensity-modulated light spot emitted by the Line Scan Tube passes through the moving lens and is focused on the film where the original image is reconstituted. The film then passes through the automatic processing equipment where it is developed ready for viewing, evaluation and storage. An indication of the capabilities of the PHOTOSCAN system can be obtained from the fact that the time interval between the acquisition of the data through the airborne scanner and the high resolution display of the same data on the ground can be reduced to ten seconds.

The Line Scan Tube specially developed by CBS Laboratories for PHOTOSCAN. The motor-driven anode rotates at 1,600 r.p.m. and provides a very fine spot of light of high brilliance.



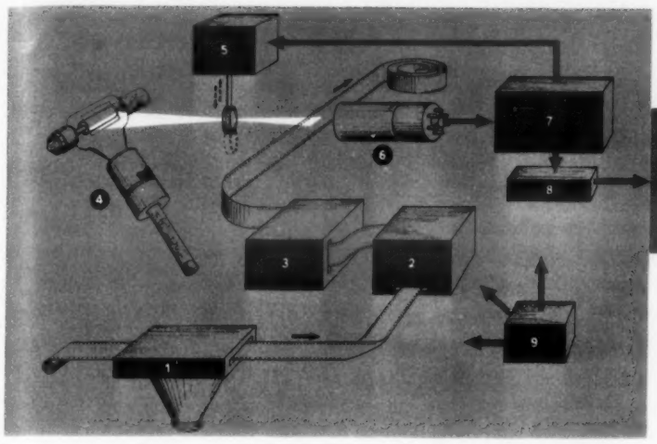
The Line Scan Tube

As the whole functioning of the PHOTOSCAN system is dependent upon the two specially developed cathode ray tubes in the airborne and ground equipment, a description of these components will assist in an understanding of the working of the system.

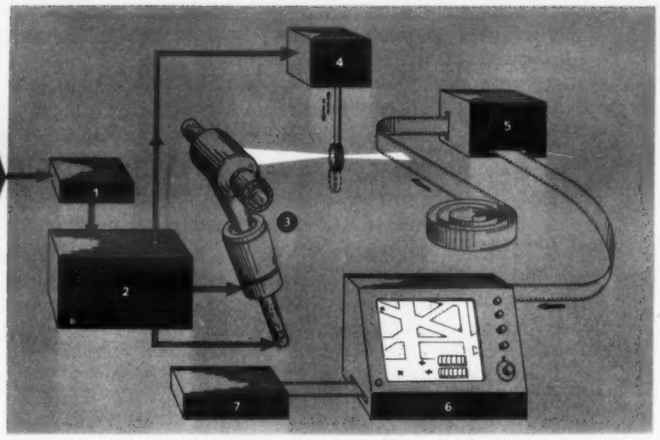
The essential requirement in both the film scanning and reconstitution processes is the provision of a cathode ray tube capable of producing a high-intensity, well-defined travelling light spot. Conventional scanning tubes used in film reproduction, which scan a single line repetitively, are subject to phosphor burns and loss of phosphor efficiency through overheating. A further disadvantage from the standpoint of a reconnaissance system is that minute irregularities which are inherent in most phosphor surfaces show up as streaks on the reproduced image. This streaking makes interpretation of the photo difficult if not impossible.

To overcome these disadvantages, CBS Laboratories developed the Line Scan Tube which contains many new features in cathode ray tube design. The tube, T-shaped in form, contains an anode consisting of a phosphor-coated revolving drum, fitted in the cross bar of the T. The incidence of irregularities in the phosphor coating is reduced during manufacture by electro-deposition of the phosphor on the drum surface. Rotation of the drum then eliminates the continuous streaks and instead a random screen pattern appears. The rotation also prevents the occurrence of phosphor burns and resultant streaking while at the same time dissipating the heat created by the electron beam over the entire drum volume. This steady heat dissipation also serves to maintain the phosphor efficiency at maximum throughout the life of the tube. Another advantage deriving from the design is that the light spot is placed on the same side of the phosphor as the electron gun. Halo effects found in conventional cathode ray tubes are eliminated, and all of the light generated by the electron beam is utilized.

The drive for the rotating anode is derived from an external electrical field. The rotor is mounted on the shaft of the drum within the vacuum tube, while the stator is fitted around the external glass envelope. This specialized design introduces a



The Airborne Scanner: 1. Camera; 2. Rapid film processor; 3. Temporary film storage; 4. Line Scan Tube; 5. Lens motion control; 6. Photomultiplier; 7. Video amplifier, synchronizing generator, scan generator and power supply; 8. Transmitter; 9. Master control unit.



Ground Receiving Equipment: 1. Receiver; 2. Video amplifier, synchronizing signal separator and scan generator; 3. Line Scan Tube; 4. Lens motion control; 5. Rapid film processor; 6. Viewer; 7. Film storage.

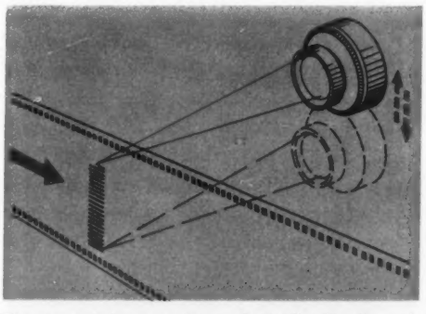
particular mechanical problem; and the dry lubrication of the shaft ball bearings within the tube represents a significant advance in the development of vacuum bearings.

The Optical Scanning System

After the generation of the travelling light spot electronically, an optical system is required to concentrate the light beam on the film. This system is basically similar in both the transmitting and receiving equipments. In the description of the aerial reconnaissance version of PHOTOSCAN, reference was made to a moving lens which traversed the beam over the film surface. This moving lens system is actually one of two alternative scanning methods which can be employed to provide the broadest possible range of applications for PHOTOSCAN. The two methods enable a choice to be made between *maximum resolution* or *maximum speed* in data acquisition and transmission. The decision to employ one system or the other is dependent upon local considerations and the type of operation that is being carried out. In the case of aerial reconnaissance maximum resolution is obviously required to simplify the task of interpretation. In this connection it should be borne in mind that the time the aircraft can spend over an enemy target is not the critical factor in deciding whether to employ the maximum resolution or the maximum speed method. A pilotless reconnaissance drone would be capable of flying over and photographing an objective and then, thanks to the film storage unit, the transmission of the photographs could proceed while the aircraft was returning to its base. The decision as to which scanning method should be employed is dependent therefore not on the time that can be devoted to the photography but the delay that is acceptable between the acquisition of the data and its reception at the base, and the degree of detail required in the finished positives.

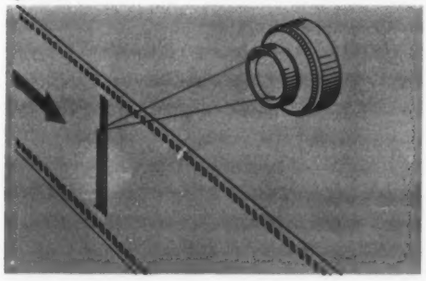
To obtain the maximum resolution the "segmentation" method is employed. For transmission, each frame is subdivided into a number of segments throughout its length. The number of segments is previously calculated in relation to the resolution desired and the size of negative used. The film transport mechanism is then adjusted to advance the film, segment by segment, with a halt for each section to be scanned. At the same time the lens is mechanically controlled so as to move in a direction perpendicular to the film travel. The travelling light spot scans parallel to the direction of the film movement, and the lens slowly traverses the spot over the width of the film. When the lens has completed its movement over the film width, it is repositioned and the film advanced one segment; the process is then repeated until the whole of the negative frame has been scanned. The film then advances to the next frame, and the transmission of the next photograph commences. While the total time required for the transmission of each complete frame is longer by this method, the reconstituted picture will reveal all the detail necessary for exhaustive interpretation.

Synchronization signals derived from the mechanical lens drive are transmitted with the video signals to control the movement of the lens in the ground receiving installation. By this means, the traverse of the two lenses is coordinated electronically.



The segmentation scanning method. The film frame is divided into segments which are scanned separately. The illustration shows the relative movements of the scanning lens and the moving light spot. The film remains stationary during scanning and then advances one segment width while the lens is repositioned for the next segment.

Non-segmented scanning. The film moves continuously while the moving light spot scans perpendicularly to the direction of film travel. The lens remains stationary during operation.



For many applications where detailed scrutiny of the transmitted photograph is not intended, the second, or non-segmentation, method will be adequate. In this simplified transmission system the scanning lens remains stationary, and the light spot scans the whole width of the film frame. To do this the light spot is focused so as to scan in a direction perpendicular to the direction of film travel, while the film transport mechanism slowly drives the film continuously past the focus point. Each successive scan of the light spot covers the whole width of the film and in consequence it is not possible to apply any contrast correction to the finished photograph. The method is, however, perfectly adequate for data transmission where speed of reception is of greater importance than depth of detail.

Possible Applications

Depending on specific requirements, PHOTOSCAN can be mounted on a wide variety of carriers and vehicles. The scanning, processing and transmission equipment can be adapted for installation in manned or unmanned airborne or space vehicles including unmanned drone aircraft or reconnaissance satellites. The range of the transmission system can be increased by the addition of one or more radio links to the communication chain. Normally line of sight distance dictates the effective range between the airborne scanner and the receiving station. This distance can be increased by the use of relay points, and these would become essential in the case of transmission between a low-flying reconnaissance aircraft and a distant ground station. This problem has been studied in detail, and proposals exist for the provision of a radio relay capsule which would be released by the PHOTOSCAN vehicle at a pre-determined distance from the receiving station. This capsule would contain a transmitter, receiver and associated antennas carried by a balloon, parachute or rocket. The choice of the appropriate aerial platform for the relay would be determined by the type, size, velocity and mission of the primary vehicle.

Apart from the military applications for such a long range data transmission system, there also exists a wide field of possible commercial and civil employment. Current advances in photographic and electronic techniques have been combined to make this high resolution image transmission possible; in this Space Age there is no lack of scope for its employment. ←→

A Canadian Doppler System

By a member of the Canadian Marconi Company

In the autumn of 1958, the Canadian Marconi Company began large scale production of a light weight airborne doppler system. The equipment has already been ordered in quantity by commercial airlines, the military services and specialized companies in the air survey world.

The sensor system consists of a transmitter/receiver, tracker, control unit, antenna and indicator. Externally the transmitter/receiver and tracker resemble almost any other airborne electronic units. The control unit is a small panel fitted with control switches for "ON" and "OFF" "SLEWING" (or setting), and "LAND/SEA" operation.

Two forms of indicator presentation are offered; a conventional circular dial with two pointers—one indicating groundspeed and the other drift; as an addition, or in place of this, a digital display may be used.

The principles upon which a doppler system is based have been described and discussed too often to warrant detailed description here. In fact the train has long passed beyond our hearing and is now presumably inflicting its doppler — shifted whistle upon some other enlightened soul.

What is of interest, perhaps, is a comparison of the various techniques employed in making use of the doppler principle in air navigation.

In these days of complexity and sophistication it is all too easy to lose sight of the fact that, paradoxically, as mechanical and electronic systems become more complicated, so it becomes of paramount importance to incorporate well proven techniques and simplicity in the blocks that go to make up the over-all system. Failure in one portion through a low reliability factor leads to total system failure, and we are left with so much dead weight—and whether solid state or not is of little consequence.

Another aspect which receives too little attention is the necessity for incorporating positive and automatic self-checking features. Invalidity in a device such as an automatic navigation system, upon which full reliance is placed and by which a high speed jet airliner is steered, must be made apparent immediately. If it is not, an uneconomic, or more seriously, a dangerous deviation from the flight path may result.

It is perhaps advisable at this point to comment in some detail on the choices facing the designer of such a device and thereafter present a detailed description of the choices made by Canadian Marconi Company in what it considers to be the best possible solution.

Faced by a formidable array of properties and choices, it appears that possibly the most important one to decide upon is the type of transmission, because no other single property appears to have such an effect on the size, weight, reliability and cost of a doppler sensor. In this connection, it very likely suffices to say that; since 1955, when the FM/CW technique was first demonstrated in a sensor by a group at Canadian Marconi headed by K.C.M. Glegg, who is now the Chief Engineer of the Commercial Products Division, all new systems (of which there have been at least three announced) have employed the FM/CW type of transmission.

There are, of course, high and low frequency versions of the FM/CW technique. However, the high frequency system has neither an altitude nor a speed limitation as is the case with the low frequency system, and so the choice of high frequency for the Canadian Marconi Company System appears to have been a reasonable one, since the device was not designed exclusively for airline use. It should, perhaps, also be mentioned that the circuit simplicity of the high frequency compared to the low frequency FM/CW solution is very striking.

The CMC system is based upon a new low noise continuous wave technique developed by the company some years ago. It also surrounds the equipment with a sufficiently large region of insensitivity so as to make it immune to the movement of any near objects which normally tend to disturb a conventional CW system. The efficiency is such as to permit it to use a transmitter of small power, i.e., half a watt.

The second choice is in the number of beams. Should there be two, three or four? The CMA-620 series of doppler sensors employs four, as this allows the maximum freedom from dependence on other instrumentation in the aircraft and, very likely, makes for the highest possible system accuracy.

The control unit of the CMA-601 airborne navigation computer. The desired track and distance of two successive flight legs can be set in the computer. When the first stage distance has zeroed, the computer switches automatically to the second stage. The third flight leg can then be set on the stage one counters.

The third choice the designer must decide upon is the type of duplexing.

With an FM/CW system, the duplexing possibilities include ferrite circulators and separate transmit and receive antennas. This is an extremely important property and one on which an enormous amount of time and effort was spent. On the face of it, the natural and straightforward choice is a ferrite circulator, but this choice needs to be carefully assessed for systems which radiate more than about 100 milliwatts per beam.

The problem with the circulator concerns the temperature range over which it can be made to work and the effect of temperature cycling on the isolation available with a ferrite circulator, bearing in mind that it must always be located with the antenna and so, in operation, is frequently exposed to the full range of external ambient temperatures.

But even as late as 1958, the use of a ferrite circulator was such an attractive possibility that, in spite of the difficulties experienced in laboratory work, it was decided to offer some systems which included ferrite circulators for evaluation with airlines. At the same time, work was continued on a parallel programme using separate transmit and receive antennas which had been started a year or so previously when first suspicions were aroused.

As a result of these evaluations, it was concluded that even with the then available half watt transmitter tubes (higher power tubes are now available), the use of ferrite circulators was not a practical field proposition, even though the CMC system of that time concluded some very successful evaluations.

The work on the separate transmit and receive antenna was completed, and systems have since been flown by many world airlines, as well as the military, with excellent results. It is not now intended to offer any more ferrite circulator duplexed units except in some very special cases since the producibility and maintainability of the separate antenna system is so enormously superior to that of the ferrite duplexed one, and the actual performance so little altered.

The next choice is between antennas that move and those that do not. The basis for choice, however, is really much more complicated than this simple statement implies. All other things being equal (sad how seldom they are), a non-moving antenna would appear to be the obvious choice. But the considerable number of advantages offered by an antenna which is maintained in alignment with the ground track by some other portion of the system, should not be too lightly dismissed.

For example, it enables a simple, direct, and highly accurate measurement of drift angle to be made. In the CMC doppler system the single transmitting array exercises the major control over antenna geometry. The receiving antenna consists of a pair of back-to-back rotating linear arrays, one forward-firing and one backward-firing, which feed a pair of parabolic cylinders. As they rotate they select left-aft and right-forward beams in one position, and right-aft, left-forward in the other. The drift angle measurement thus utilizes in effect the same portions of the antenna on left and right portions of drift measurement; thus any manufacturing variations in the antenna are self-cancelling.

Finally, the moving antenna has the advantage of requiring but one tracker. There is even more to this advantage than appears at first sight. This is related to the self-checking feature which is considered to be mandatory in a doppler system. In a moving-antenna system such as the CMA-620 series, it suffices to check whether the tracker is tracking in order to be able to place reliance of a very high order on the output data. This is done by systematically perturbing the tracking oscillator frequency and observing whether it attempts to reacquire the center of the spectrum. Symmetrical perturbation ensures no loss of tracking accuracy. By comparison, fixed antenna systems would require three different perturbations, and even then it is not the output data that are checked but only the information from which these data are calculated.

No discussion of fixed versus moving antennas for doppler sensors would be complete without mentioning the question of mechanical complexity. The choice of fixed versus moving antenna is not simply a choice between machinery or no machinery, but rather between locating a fixed amount of machinery in one place or another. In any case, it is not entirely advisable for electronics systems manufacturers to acquire the tendency to eliminate as many mechanical devices as possible to the detriment of system performance; claims of poorer reliability or maintenance difficulties are simply not borne out in practice. In the final analysis the inherent quality of a design employing mechanical devices can only be assessed in the light of sustained performance within the manufacturers' published specification. This the Canadian Marconi Company doppler system sensors have more than done in their record of operation for many thousands of hours, well within specified performance, and with no deterioration of the antenna or any other portion of the system.

The next choice to be made is in the matter of tracking, but as there are at least two senses in which the term is used, a brief attempt at clarification is perhaps in order.

Although one speaks of the doppler shift which is obtained from the receiver of a sensor, one does not in fact obtain anything approaching a single frequency. What is actually obtained is a comparatively broad spectrum standing against a background of noise.

This situation gives rise to the necessity for tracking, which consists basically of a process by which the noisy wide spectrum can be replaced (tracked) by an essentially noise-free monotone having a frequency corresponding to the frequency of the maximum of the doppler spectrum. The term "tracking" is sometimes used to denote this process and no more.

However, the term is also sometimes used to include the process whereby an analogue is established between the frequency of the tracking oscillator and some parameter such as the angular position of a powered shaft by means of which a visual, repeatable display of groundspeed can be obtained.

The CMA-620 series employs a single audio frequency tracker. It delivers groundspeed in a variety of forms (synchro, potentiometer, cycles) and also provides a control signal for aligning the antenna with the track. The drift angle is, of course, obtained directly from the antenna as a synchro signal.

A further, and most essential, property has already been mentioned. This is the real significance of the "ON-OFF" flag—or, what is more to the point, the real significance of the "ON" indication. The operator of a fully automatic navigation system should not have to continually ask himself if indeed the system is giving the correct answers just because it is indicating itself to be "ON." The procedure adopted by CMC, generally called "LOCK CHECKING," is conducted automatically and continuously and will give a fault indication within about 20 seconds of its occurrence. The perturbance of the tracker is, of course, in no way apparent on the indicator.

A great deal of both laboratory and in-flight experience with the "LOCK CHECK" procedure indicates that it constitutes an extremely effective and valid check of the trustworthiness of the output data.

It is well to remember that no matter how carefully and well a device is designed and built, it will inevitably suffer failures. Once this fact is acknowledged by a manufacturer of such devices, it then becomes "fair practice" to ensure that a failure cannot be ignored by failing to represent itself as such. This will become more and more evident to the operators of such equipment as their dependence upon successful operation becomes more extensive and complete.

Finally, a word should be said about that problem plaguing all doppler systems no matter what the design technique. This is the situation in which loss of signal occurs due to smoothness of the reflecting surface (more usually associated with smooth sea but also possible in the case of smooth desert, snow or ice).

The problem here, when assessed in the ligth of the operator's increasing reliance upon the system, is not solely the subsequent over-all decrease in percentage accuracy which results from extended outages, but in the light of our experience, some emphasis should be placed on the concern aroused in the crew when their "fully automatic" system goes "OFF" without any indication of the likelihood of it going "ON" again.

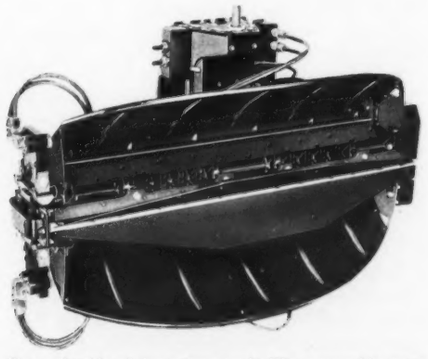
The use of a "Smooth Sea Mode" is an attempt at reducing these two problems to the extent where they are negligible.

The smooth sea mode operates as follows. When operating normally, the CMA-620 series employs four beams radiated at an angle with the vertical which is chosen to yield acceptable groundspeed accuracies. When the tracker fails to track, the sensor automatically reverts to a two beam system in which the two beams in use are pointed down more steeply at the water by tilting the antenna in pitch. This has the effect of increasing the signal return from the water by about 15 decibels and by so doing allows tracking to be resumed. In this mode, the antenna is positioned in drift with essentially the same accuracy as normally, and the groundspeed is also measured, but with reduced accuracy (3 to 5 percent).

At roughly one minute intervals the sensor automatically returns to its normal state and checks if operation is possible, and if it is, the system remains in the normal state.

This has turned out to be a very well received feature of the equipment, and this appears to be attributable as much to the reassurance which it provides the crew as to the continuity and hence accuracy improvement (especially in drift) which this mode of operation provides. It will be readily recognized that this mode of operation very effectively exploits both the FM/CW and the moving antenna properties of the CMA-620 series.

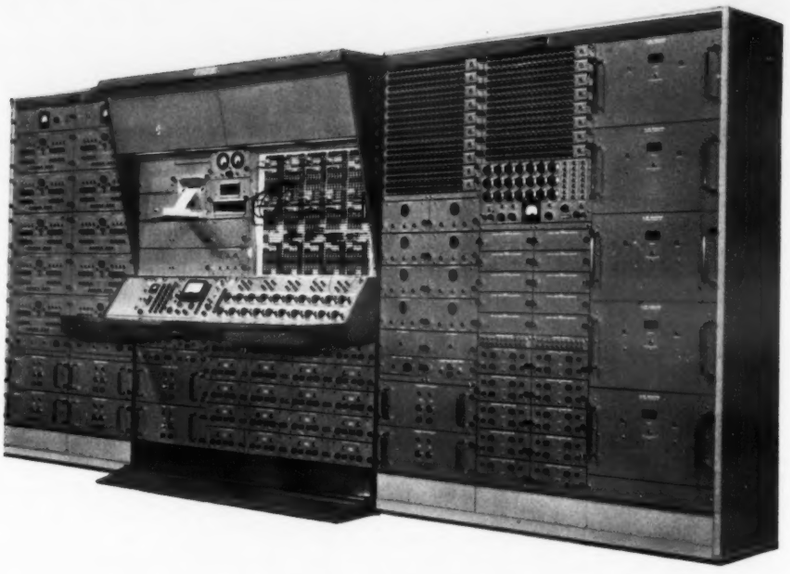
It will doubtless be appreciated from the foregoing that the engineering compromises in a doppler sensor are numerous and complicated. In fact, as will now be readily appreciated, it is not possible and was not intended to discuss all the properties, characteristics and desirable features of a doppler system. However, it is hoped that, whether you view the problem from the standpoint of a user or a designer, this description of the Canadian Marconi Company Doppler System has served to indicate the magnitude of the effort which has gone into the device.

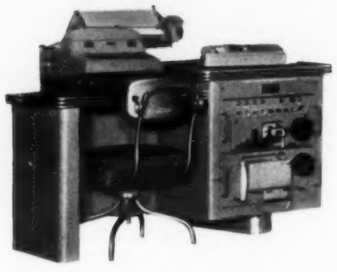


The underside of the antenna unit. The waveguide array is automatically maintained in alignment with the aircraft track while the longitudinal axis is kept horizontal by means of a mercury switch actuated servo-motor.

The final assembly of the doppler sensor antenna.

The PACE 231R with its 0.01 % accuracy represents the latest standards for speed, accuracy, flexibility, reliability and economy in the field of analogue computation. It can handle everything from the complicated details of routine engineering problems to the most complex and sophisticated missile designs. It is shown here with its associated ADIOS (Automatic Digital Input Output System). *(Fig. 1)*





Computing and the Aeronautical Industries

By R. J. Gomperts, M. A., Lic. ès Sc., and Dr. E. B. Naschke, Electronic Associates, Inc., European Division, Brussels

It is probably fair to say that the aeronautical industries were the first to realize the importance of computing as an engineering tool. It is to their credit that, having appreciated this need, they called for and utilized computing machinery industrially.

There has never been a clear-cut decision to prefer either analogue or digital methods or machines. Historically the two methods developed in parallel, and the choice of equipment was dictated either by convenience or familiarity, e. g. while engineers used slide rules and log tables, the weights office probably utilized desk machines.

Analytical solutions were sought to obtain drag and pressure distributions for various shapes of aerofoil. These were computed afterwards. On the other hand, rheological methods such as electrolytic tanks and conducting sheets were developed for just these problems. Stress calculations have been tackled from time immemorial by numerical methods, although for problems with distributed parameters, resistance networks—i. e. an analogue method—have proved very attractive. When flutter problems were first analyzed one used the powerful methods of matrix calculus, but the numerical work involved was such that flutter simulators soon appeared. These were analogue machines, solving systems of simultaneous differential equations. A fair amount of mechanization was introduced to simplify the setting of the coefficients, especially those depending on the velocity parameter. These machines took the sting out of flutter problems.

When aircraft control problems came to the fore, there was again a parallelism between digital and analogue methods, and this time the simulator or analogue computer decidedly established a lead over numerical methods. Other problems such as noise and vibration analysis were treated both digitally and analogue wise. Using the former method one obtains a frequency spectrum derived from a correlogram, while in the latter case the spectrum results from squaring the signal and subsequent filtering. This latter method has become increasingly popular.

Briefly then, the situation was that numerical and analogue methods both had their place in the armoury of the aeronautical engineer. Although many claims to the contrary have been made, the advent of the general purpose digital machine has not altered this situation in a material manner, in spite of the magnificent electronic engineering effort it represents. The analogue computer and the digital machine are still complementary, both have their correct utilization, each can do certain jobs better than the other, each is rather unhappy in having to carry out the other's speciality.

The stressing of aircraft structures is a job better left to a digital machine, so is the day-to-day work of the weight office which is essentially a clerking operation. On the other hand the digital computer does not perform well with aircraft stability problems, control involving the whole aircraft or missile with its autopilot and perhaps navigation and fire control equipment. This is just the province of the analogue computer.

At this stage, one may well ask what causes this difference in aptitude? This may be summed up as follows: A digital computer is an automated desk machine calculator, the operator being replaced by the program which contains all the instructions. However, and this is its great strength, one need not write down *all* the instructions: it can modify its own instructions provided it is told to do so. Nevertheless, its great limitation is that virtually all modern machines have only one arithmetic unit, and therefore all the computations must occur sequentially even when in practice they occur simultaneously.

With an analogue machine the situation is rather different. There the machine represents the same mathematical equations as those which describe the problem under study. Thus the sequence of events is the same as for the real problem.

It is difficult to state simply what the effect is of this difference in method of operation, but the following hypothetical problem might illustrate the point.

The response is wanted of a given non-linear system to a number (five) of specified sinusoidal inputs which are in the one to ten cycle per second region.

Modern high class analogue computers can tackle this problem in real time and simulate the excitation to an accuracy of 0.01 percent. Using the best types of non-linear equipment, the system parameters can be represented with the same accuracy. The response obtained will then have an error of the order of 0.1 percent or less.

Now consider what is required for the digital solution.

To represent a sine wave of frequency f by a series of samples, so that the time series of samples never deviates from the true signal by more than x percent of the amplitude, requires

$$N = \frac{100 \times 2\pi f}{x}$$

samples per second.

For $f = 10$ c/s $\quad x = 0.01$ one obtains $N \cong 6 \times 10^5$ samples per second.

If one wishes to work in real time one needs therefore 6×10^5 samples per second. But each sample is a word which must consist of at least 20 bits to cater for the order code and the number of bits required for an accuracy of 0.01 percent. The clock frequency, which is the fundamental pulse frequency of the machine, must therefore be of the order of tens of Mc/s for a completely serial machine. But this is the frequency required to present only one frequency in real time. If, say, 5 fre-

quencies are to be scanned at a rate so that the whole excitation signal appears in real time, then the clock rate must be 5 times faster. So far no account has been taken of all the operations required to represent the non-linear system itself. This will introduce further delays, and if one still wishes to operate in real time the clock frequency has to go up further still.

This is not done presently for engineering reasons, and consequently for this problem the digital computing rate will be many times slower than the analogue rate if the same accuracy is to be maintained. The ratio of these computing speeds can be very considerable, and for problems where a great number of cases have to be considered this may constitute a real handicap.

However, it must be stressed that a digital machine has inherently a greater accuracy.

Nevertheless, there is a place for both types of computer in the industry. While the performance of the large digital machines is fairly well known as they are used for administrative purposes as well, this is not the case with analogue machines. It may, therefore, be of interest to mention here the state of the art achieved for general purpose precision analogue computing equipment.

The accuracy of the linear units is of the order of 0.01 percent of full scale or better, with a bandwidth that extends into tens of kc/s. The performance of non-linear equipment is not as good yet, but accuracies are improving. There are now fast multipliers on the market with an accuracy of 0.01 percent, and for specific applications 0.01 percent can be achieved with special purpose function generators.

Fig. 1 shows such an installation with 100 amplifiers and a complement of function generators, multipliers, resolvers, and other non-linear equipment.

Often a high speed repetitive facility is provided. By this means a problem can be solved on a speeded-up time scale, and a number of solutions can be viewed on an oscilloscope.

The Dataplotter is a complete digital-to-analogue reduction system. It converts inputs from keyboard punched cards or punched tape into analogue data for plotting. Data output is either in the form of point plot (12 different symbols; 60 points per minute; accuracy 0.05 %) or continuous line plot (more than 30 points per minute; accuracy 0.1 %). When used as line plotter it receives information from the punched cards or punched tape and in less than 2 seconds digests the information from the next card, recalls the first information and then automatically draws the line between the two points. A model using input data from the magnetic tape is also available. *(Fig. 2)*

On the other hand there is a requirement for a much smaller type of computer capable of solving typical servo problems and where a lower accuracy can be tolerated.

A number of manufacturers have brought out equipment of this nature, but the one illustrated in *Fig. 3* combines the requirement for a small computer with the latest design techniques. This computer is completely transistorized and contains fully expanded 20 amplifiers, 24 potentiometers, 4 non-linear units, etc. A number of these computers can be combined. The accuracy is 0.1 percent of full scale ($\pm$ 10 V), and the total power requirement is less than 50 W.

One of the big problems facing the users of analogue computers is the utilization factor. The machines can be immobilized for a long time setting up problems, whereas on the digital machine all setting up can be done away from the machine, apart from program testing. Though the establishing and debugging of the programme can take a very considerable time, this is carried out away from the machine which is free to be utilized for other problems. With analogue computers there is a similar situation in that a considerable amount of preparatory work can be done in getting the problem ready for the machine, and the work to be done on the machine can be reduced to setting of parameters and reading a number of check voltages. However, even this can involve a very considerable amount of time, thereby immobilizing an expensive installation.

Modern design trends are overcoming this problem by automatic setting of potentiometers from perforated type or punched card machines and offering print-out systems which can be manual or automatic. This last feature means that the output of all the relevant units is scanned, read and printed out. In this way the test time can be reduced very considerably, since if the check is not correct the problem can be taken off the machine—leaving it free for other users.

The desk unit shown on the left hand side of *Fig. 1* is a punched tape control desk used in conjunction with the automatic potentiometer setting and read-out system.

It is often required to convert the information obtained from digital machines into graphs. *Fig. 2* shows an equipment which is capable of handling punched tape, punched cards or manual digital data, and transforming these data into graphs. This plotter is also used for converting telemetry data.

Combination of analogue and digital techniques does not extend only to terminal equipment but has taken a more extensive form. This has come about because there are obviously problems where some parts of the problem are preferably done digitally and other parts analogue. To meet these demands one requires the two types of machine and link systems which have the function of connecting the two computing systems. The role of these links is essentially that of a translator. It is difficult to generalize on this problem as each case must be treated on its own.

Such translator or interpretor systems have been built, and at present there are several combined analogue-digital systems in operation where a PACE 231R is working with a digital computer*.

This is certainly a vindication of the main thesis of this article that either computing method, whether digital or analogue, has its field of application. By combining these methods where necessary, one makes the best of both worlds. ←→

To make analogue computation easily accessible to every engineer and let him obtain first-look solutions especially on dynamic problems in a fraction of the time they normally take, Electronic Associates, Inc., has developed a low cost all-transistorized analogue computer, the PACE TR-10 that has an accuracy of 0.1 % and occupies little more desk top area than a standard electric typewriter. Typical areas of application for the TR-10 in the aero/space field are the study of guidance, control, and propulsive systems, electronic circuitry, radar detection and ranging, and data acquisition. *(Fig. 3)*

* So far Electronic Associates has carried out link-ups of its PACE 231R equipment with an IBM 700 series machine, a Remington Rand machine, a Datatron and a Bendix computer. It should be noted that the higher the clock frequency of the digital machine the easier the link-up.

Rockets, Missiles and Space Vehicles

The Martin Company's *Bullpup* trainer missile, which is to be flight tested from a Martin B-57. The USAF is to use the missile on the North American F-100 *Super Sabre*.

New Falcon air-to-air missiles

GAR-3A and GAR-4A *Super Falcon* are the designations of two new and hitherto secret versions of the Hughes *Falcon* air-to-air missile. The GAR-3 has a semi-active radar homing head, while the GAR-4A is fitted with a new type of infra-red homing head which, being more sensitive, can seek out smaller and more distant targets than its predecessor. Both versions are 7 ft long and 6.5 in. in diameter and weigh 145 lb. No details of their new solid-propellant motor, jointly developed by Thiokol Chemical Corporation and Hughes Aircraft Company, have yet been issued. Designed for use by Convair F-106A *Delta Dart* interceptors, the *Super Falcons* can be launched at speeds of up to Mach 2. The F-106A can carry four *Super Falcons* and one Douglas MB-1 *Genie* air-to-air guided missile. In addition to USAF orders already received for fiscal 1960, totalling $30 million, Hughes has received further contracts to the value of $36 million for fiscal 1961. The weapons will be manufactured at the company's Tucson, Arizona, plant.

The newest member of the *Falcon* family is the GAR-11 *Nuclear Falcon*. This radar-guided air-to-air missile with nuclear warhead is being manufactured at Tucson under a $23 million Air Materiel Command contract. The first deliveries to Air Defense Command are scheduled for some time this year. The 7 ft *Nuclear Falcon*, with a maximum diameter of 11 inches, and weighing just over 200 lb, is to equip the Convair F-102 *Delta Dagger* all-weather fighter, which will require only slight modifications to take the missile.

Bullpup trainer missile

A stockpile of obsolete HVAR solid-propellant rocket motors from World War II is being used to cut the cost of *Bullpup* air-to-surface trainer missiles being produced by The Martin Co.'s Orlando Division under a $700,000 USAF contract. The weight of the 8 ft *Bullpup* trainer is about 125 lb, i.e., only one fifth that of the operational weapon, the GAM-83A. It has, however, the same aerodynamic characteristics and the same range and accuracy.

It is possible that the operational version will be used to equip fighter bombers of the Japanese Air Self Defense Force. *Interavia*, No. 5/1959, p. 525, contained a report on the various versions of the *Bullpup*.

The Hawk throughout the world

In mid-April representatives of the Raytheon Company and Société Européenne de Téléguidage (SETEL) signed an agreement in Washington covering European licence production of the *Hawk* ground-to-air guided missile. The SETEL group consists of the following firms: Ateliers de Constructions Electriques de Charleroi (Belgium); Compagnie Française Thomson-Houston (France); Microlambda—represented by Società Industriale Prodotti Elettronici, Nuova San Giorgio, all three firms controlled by Finmeccanica, plus Fiat, Bombrini Parodi-Delfino and Fabbrica Italiana Apparati Radio (Italy); NV Philips (Netherlands); Telefunken GmbH (West Germany). Final assembly of the *Hawk* will take place in France.

In Japan a group of six firms, headed by Mitsui, is to found a concern to be known as the Japan Rocket Company, which will produce the *Hawk* and the SSM-A-12 *Lacrosse* (surface-to-surface missile). Participating in the venture are Tokyo Shibaura, Fuji Heavy-Industries, Japan Steel, Tokyo Precision Instruments, Dai-Nippon Celluloid and Mitsui & Co.

Northrop Corporation has received contracts from Raytheon totalling $22,647,800 for continued production for the U.S.Army of the *Hawk* system's mobile launcher and missile loader and major portions of the airframe, controls and special transport pallet. The work is to be carried out at the Nortronics Division's Anaheim plant. Temco Aircraft Corporation is to supply *Hawk* stabilizers and accessories to the value of $2,184,000.

◀ Members of the Hughes *Falcon* air-to-air guided missile family: *left to right*, GAR-11 *Nuclear Falcon;* GAR-2A and GAR-1D *Falcon;* GAR-4A and GAR-3A *Super Falcon.*

New Soviet satellite

On May 15th the Soviet Union successfully placed a new *Sputnik* in a near-circular orbit around the earth. According to the news agency Tass, the satellite weighs 9,980 lb; it contains a pressurized capsule weighing about 5,500 lb with a load equivalent to the weight of a man, and all equipment necessary for manned space flight. The weight of other instrumentation and power supply, including solar converters and chemical batteries, is 3,250 lb. The transmitter operates on a frequency of 19.995 Mc/s and transmits signals of fluctuating length at irregular intervals. The new satellite is reportedly circling the earth at a height of between 184 and 229 miles and is visible to the naked eye. The orbital period is 91.2 minutes, the angle of trajectory 65°. Although there is no intention to recover the capsule, it is to be released from the satellite by a signal on completion of the measurements, when it will fall earthwards and burn up in the lower layers of the atmosphere.

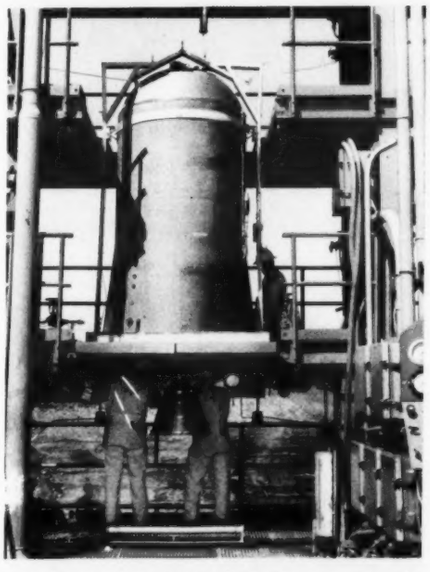
A new version of the M3 *Hawk* anti-aircraft rocket with modified cruciform wings. Fitted with a semi-active radar homing head, the *Hawk* can reach speeds of Mach 2.8 and over, and was the first surface-to-air weapon to destroy an *Honest John* ballistic missile in flight.

Development of Saturn booster

The U.S. National Aeronautics and Space Administration has awarded the Douglas Aircraft Company, Santa Monica, California, a $65 million contract to build nine second stages for the three-stage, 165 ft *Saturn C-1* booster. There were eleven bidders for the NASA contract, including Bell, Boeing, Convair, Grumman, Lockheed, Martin and Pratt & Whitney.

The second stage will have a diameter of 18 ft and a length of 55 ft. Power will be supplied by four clustered Pratt & Whitney *Centaur* engines developing a total thrust of 80,000 lb. Douglas will build the second stage at Santa Monica and, since it is too large for transport by road or rail, it will be sent by sea first to a test facility near Sacramento, and later to Cape Canaveral via the Panama Canal.

Of the eight Rocketdyne H-1 motors comprising the first stage (derivations of the S-3D rocket powerplant used on the *Jupiter* IRBM), first two, and then four, were simultaneously fired at Huntsville; this was followed by the successful testing of all eight motors. The thrust of each motor is said to be of the order of 188,000 lb. Later versions of the *Saturn* will have a clustered first-stage powerplant with a thrust of about 2 million pounds. The first stage fuel tank system

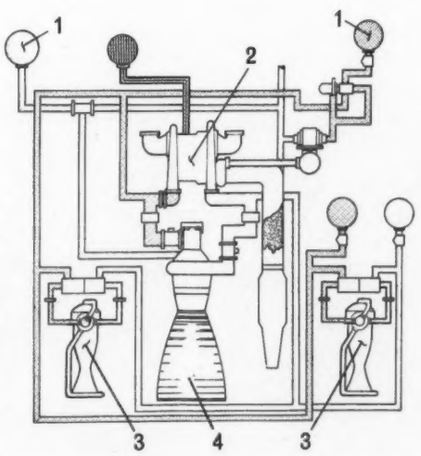


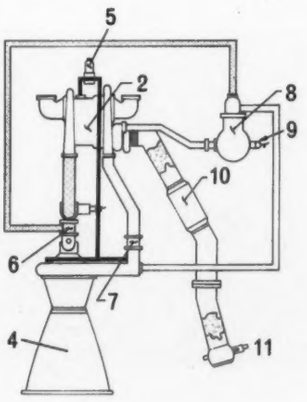
Engineers of Aerojet-General Corporation preparing the *Able-Star* second-stage liquid rocket engine for a test run. Developed by the Systems Division of Azusa, California, this engine, in combination with a *Thor* first stage, put the *Transit 1 B* navigation satellite into orbit on April 13th (cf. *Interavia*, No. 5/1960, page 614). The *Able-Star* is the first American rocket motor which can be restarted in flight.

can supply the powerplant system with a total 340 tons of liquid oxygen and RP-1. The final version of the first stage will be fitted with auxiliary devices for the recovery.

No contract has yet been awarded for the construction of the third stage, but this is expected to be a modified second stage of the *Centaur* space vehicle (cf. *Interavia*, No. 1/1960, p. 53), 10 ft in diameter and powered by two lox/liquid hydrogen engines delivering a combined thrust of 30,000 lb.

The *Saturn* booster is to be built in three basic versions. The *Saturn C-1* is to put a payload weighing 4,500 lb into a 24-hour orbit around the earth or to land a 2,400 lb payload on the moon. The C-1 could also be used to launch a boost-glide vehicle such as the *Dyna-Soar*. The projected four-stage *Saturn C-2*, total length 230 ft, is to have a second stage with a two-chamber lox/liquid hydrogen engine of 200,000 lb thrust. Designs for the second stage have been submitted by Bell, General Electric, Pratt & Whitney, Aerojet-General and the Rocketdyne Division of North American Aviation. The C-2 version will be designed to carry a payload of about 15,200 lb outside the earth's gravitational field, put 9,000 lb into orbit around the earth or place a 5,000 lb payload on the moon. A five-





North American's Rocketdyne Division has made a series of thorough tests on its X-1, with the aim of simplifying liquid rocket engines. Left, the simplified powerplant, right the original engine (to left of picture) with the simplified version. 1 – heat system, 2 – turbopump, 3 – vernier engines, 4 – thrust chamber, 5 – additive lubrication unit, 6 – oxidizer valve, 7 – fuel valve, 8 – gas generator, 9 – turbine starter, 10 – heat exchanger, 11 – turbine exhaust for roll control.

stage version, the *Saturn C-3*, is also planned, the last stage to have nuclear propulsion.

To speed up the development of Saturn, a second stand is to be built at Huntsville for testing the clustered first-stage motor at maximum thrust. The first *Saturn* launching pad, scheduled for completion later this year, is being built at Cape Canaveral missile range. About 300 yards from this installation the dome of the two-storey control blockhouse is going up.

According to Brigadier General Don R. Ostrander, Chief of NASA's Office of Launch Vehicle Programs, the *Saturn C-1* test programme will be as follows: three launchings with live first stage and dummy second and third stages, three with live first and second stages and three with all stages firing. A tenth test would determine whether the *Saturn* could be declared operational. Present estimates of the development costs for all ten rockets are almost $890 million.

Dyna-Soar contract for Boeing

Boeing Airplane Co. is to build eleven *Dyna-Soar* boost-glide vehicles under a USAF programme announced at the end of April; three of the vehicles will be used for ground tests, four for unmanned flight and four for manned flight. The first unmanned flight of a *Dyna-Soar* prototype is scheduled for September, 1963, when the vehicle will be released from a Boeing B-52 at a high altitude. The first manned flight is scheduled for 1964; for this purpose the *Dyna-Soar* will be launched from the ground by a modified SM-68 *Titan* ICBM. The total development costs are estimated at $480 million, of which the USAF has so far received $65 million. Further credits of $58 million have been requested for fiscal 1961, $151 million for 1962 and $206 million for 1963.

Initially, the *Dyna-Soar* is intended purely as a research vehicle. Its development is to be carried out in several phases, with the first version weighing about 6,000 lb and designed to reach speeds of around 15,000 m.p.h. The second (manned) version will be 30 percent heavier. In the third phase the boost glider is planned to weigh about 15,000 lb and may possibly carry a crew of two. Finally, it is intended to develop the research vehicle into a global aircraft carrying nuclear warheads or photographic and infra-red reconnaissance equipment.

Minuteman Weapons System

The launching of an eighth SM-80 *Minuteman* ICBM from a silo at Edwards AFB, California, on May 6th, marked the successful conclusion of an Air Force Ballistic Division test series begun in autumn, 1959. The purpose of the tests was to determine the optimum design for the silos, paying particular attention to the problems of noise, heat, blast and vibration. Experiments on the guidance system, which was exposed to exceptionally high loads on a rocket sled, gave satisfactory results. To accelerate the development and testing of the *Minuteman*, the U.S. Air Force has asked for additional appropriations of about $500 million for fiscal 1960 and 1961; these funds would be diverted from other projects.

Launching of a *Minuteman* prototype. As this firing was designed solely to test the launching installation, the second and third stages were dummies. The first-stage motor ran for only a few seconds, and a nylon tethering cable checked the missile's flight at an altitude of several hundred feet.

A *Minuteman* launching silo at Edwards AFB.

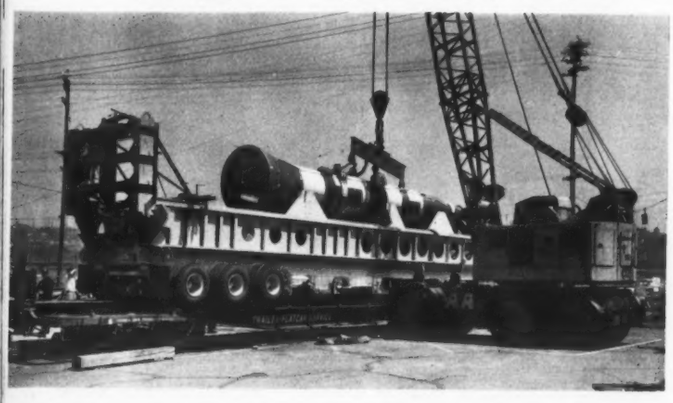
The projected *Minuteman* units are to be as follows: Out of about 800 missiles to be procured, 550 are to be stationed in underground silos, the remainder installed on railway trucks. As, according to unofficial reports, each *Minuteman* squadron is to comprise fifty missiles, the 800 weapons would be distributed among 16 squadrons.

The estimated cost of equipping the static units with the production version of the *Minuteman* is about $1.5 million per weapon, and the costs of constructing the launching silos will be about $20 million per squadron. The USAF has selected Malmstrom AFB, Great Falls, Montana, as the site for its first *Minuteman* operational units. In 1961 construction work will begin on underground silos for three squadrons; on completion, the installations will be transferred to Strategic Air Command.

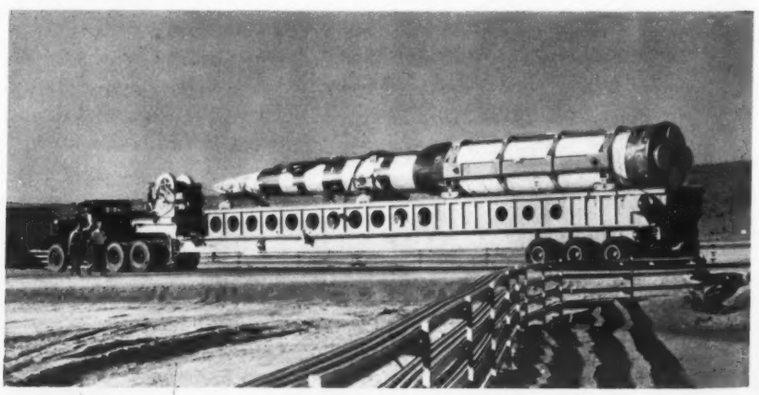
The price of a mobile *Minuteman* is about $3 million. To gain experience of the mobility of missiles on railway trucks, the Ballistic Missile Division and Strategic Air Command are to send an experimental missile train on six trips through the mid-western and western states of the USA.

A large number of contractors are involved in the project. Boeing Airplane Company is responsible for assembly and testing. The solid-propellant rocket motors for the three stages are to be supplied by: Thiokol Chemical Corporation (first stage); Aerojet-General in collaboration with Thiokol (second stage); Aerojet-General or Hercules Powder (third stage). No information has yet been received on the thrust performance of the individual engines. Autonetics is building the inertial guidance system, Avco Corporation is producing the nose cone. The overall length of the *Minuteman* is 60 ft, the launching weight some 85,000 lb, the range over 6,000 miles, the payload a nuclear warhead. *Interavia*, No. 5/1960, page 613, contained a report on the *Minuteman* transport system. ⟷

Dummies of the two upper stages of a *Minuteman* test missile being loaded onto a railway truck at Boeing Airplane Company's Seattle plant.



A complete *Minuteman* on its transport stand on the way to Edwards AFB, where it was used in silo development tests.



working pilot

The IFALPA delegate speaking to the ICAO Special Meeting, Montreal, February, 1959.

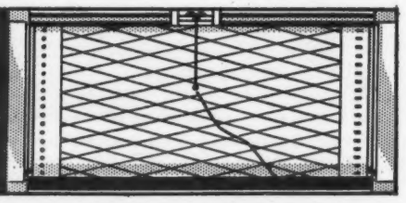
"We do not have any difficulty with the words 'Area Coverage' but apparently some people do. In general terms what it means is the ability to navigate in any part of an area with precision. We feel that pictorial presentation is a proper part of an area display.

The present standard in high density areas has been most highly developed and used in the U.S.A. The New York area is an area of high traffic flow, and it is appropriate to review the functioning of the present system in its most complete form and where it is under the most severe test. We are most concerned with the ability of VOR to provide what we feel is essential in high density areas—helicopter cover and aid for high flying aircraft.

In the area there are 34 stations which use 33 frequencies, and aircraft flying at 40,000 feet in the area will, under normal conditions, hear all of them. Basically he will hear the 34 stations in the area, and under abnormal conditions also those in the area to the West and South; a total of 69 stations using 60 frequencies.

I might mention that we have a problem with frequencies — we have apparently exhausted them in this area. We also have a problem with low frequencies. The power of some low frequency beacons is quite low, so that you can usually not tune them in until you reach some-where in the neighbourhood; you will not get an A.D.F. signal until you are perhaps six or seven miles away, and occasionally pilots have gone right over them without picking the signal up. Our proposal for area coverage would surely not solve every problem, but it does offer some potentials for solving this and similar problems."

THE DECCA NAVIGATOR



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Controllable Solid Rockets for Space Vehicles

By Kurt R. Stehling, NASA, Washington, D.C.

The development of chemical propulsion is presently proceeding along two paths: (a) liquid, and (b) solid propellant propulsion. At the moment the liquid systems have several advantages over the solid, as follows:

1. Longer development background during the past two decades, even though the very first rockets of all were solid.
2. High combustion efficiencies or "specific impulses."
3. Long burning times—with regeneratively or propellant cooled engines the burning time can be anything the engineer wishes.
4. Start-stop capability—i.e., stop on command. Reignition capability.
5. Thrust level control or throttling.
6. Thrust vector control, usually these days by gimballed thrust chambers.
7. Electric and hydraulic power generation when gas turbine propellant pumps are used. The gas turbine exhaust can also be used for roll control via small exhaust rocket jets.
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These are massive and critical advantages and have resulted in the predominance of the liquid propulsion systems for missiles and space applications. Yet, with these advantages have come many problems. Mainly these have occurred in the area of reliability (or lack of reliability!) resulting from the aggregate of flow controls, plumbing, pressurization systems and propulsion electrical controls. Thus many failures of boosters and other liquid propellant vehicles can be traced to malfunctioning of such elements; relatively few liquid propulsion failures are caused by engine burn-through these days.

The solid rocket, by virtue of its simplicity, does not have the problems of sub-component failure; however because of the very fact of its simplicity and lack of moving parts it is less flexible than the liquid and in the past has been mainly used as a one-shot propulsion device, with no attempt made to build into it any of the control features listed above for liquids.

However, with the growth of solid propellant technology and the realization by space and missile engineers that reliability is an all important factor, the solid propellant proponents are thinking of ways and means of extending the usefulness of the solids.

At the moment it does not seem possible to bring the specific impulses of solid propellants up to that of such liquids as fluorine-hydrazine, hydrogen-oxygen, or even nitric acid-hydrazine. It is difficult to adjust ratios in solids to raise their specific impulses to be consistently equal to that of medium-energy liquids such as the aforementioned hydrazine-nitric acid combination. However, progress is being made, and in a few years the best solids will have specific impulses equal to the best "intermediate" liquids.

In the meantime, various improvements in the solids' mechanical or control characteristics can be made. Let me first list those elements which will at once increase the versatility of the solid and make it applicable to various space missions which are at present closed to it:

1. Start-stop on command.
2. Thrust level variation.
3. Thrust vector control.
4. Start-stop and reignite on command.
5. Stop on command and retro fire.

It is to be noted that these *mechanical* additions to the simple solid rocket are not *all* necessary for most missions, and indeed it is unlikely that more than two of these elements would be needed for any one space undertaking.

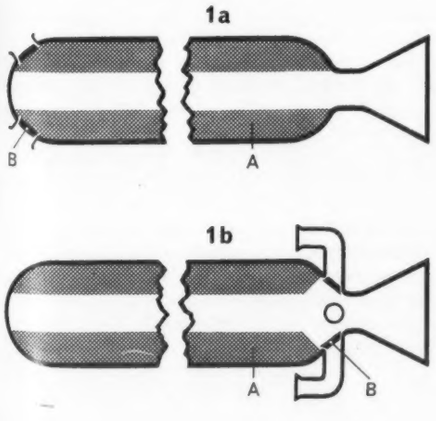
I shall discuss in brief detail the ways and means of achieving these solid rocket controls and their usage.

1. Start-stop on Command

A solid rocket can easily be started on command—which is nothing more than a simple ignition process! This, therefore, is no great problem. However, it is much harder to *stop* a solid when desired. Usually in most space missions, as in the *Vanguard* Stage III, the solid rocket was loaded with just enough propellant grain to give the desired total impulse or velocity increment, assuming a certain inert parts weight.

Yet for larger solids where case and propellant weights are difficult to control exactly, it is desirable to provide an exact and positive velocity cut-off. To do this one must quench the combustion process almost instantaneously at the desired shut-down time and thus terminate the thrust. There are two schemes possible here (see fig. 1). It can be seen that these schemes depend on venting the combustion gases through frangible discs which are ruptured on command from the signal generated by an integrating accelerometer or a telemetered cut-off signal. In experimental tests it has been demonstrated that thrust can be terminated in a fraction of a second fairly reliably and predictably. However, there are some interesting problems remaining such as thrust asymmetry caused by uneven rupture time of the discs, and propellant burning instability during the period of venting, causing thrust oscillation; also the mechanical mounting of these discs in the walls of the chamber raises a complicated design problem.

Thrust termination is most useful for precise velocity control of certain ballistic and space missions where velocity accuracy must be held to a few feet per second.

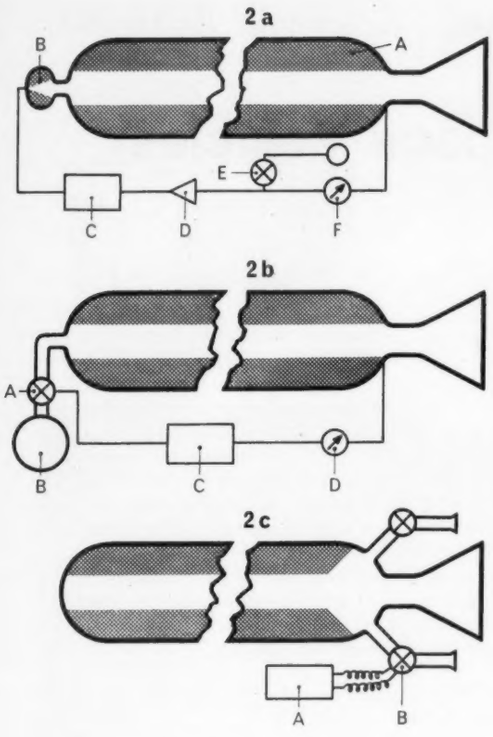


Proposed methods of thrust cancellation. Frangible explosive discs mounted in the walls of the rocket chamber are exploded on command and vent the gas. Diagram 1b shows a variation of the scheme more conveniently placed remote from the payload or preceding stage.

A. Propellant grain
B. Frangible discs

2. Thrust Level Variation or Control

By the nature of their combustion processes, rocket engines "resist" throttling or thrust control. The latter is difficult enough to achieve in liquid rockets, where it is possible to control the flow rate of liquid propellants by regulating valves or by changes in turbo-pump output. In the solid rocket this matter is much more difficult since here the very simplicity of the solid prevents the use of flow controls for throttling. Once the combustion



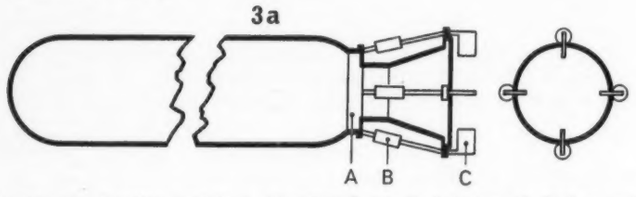
Three methods of thrust level variation

2a: Sonic thrust control
A. Propellant grain
B. Sonic whistle introduces sound into combustion zone to influence burning rate and chamber pressure.
C. Sonic generator
D. Amplifier
E. Pressure adjustment
F. Actual pressure indicator

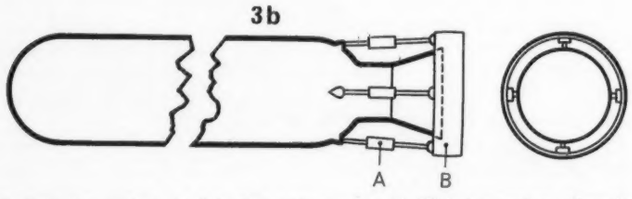
2b: Inert gas bleed control
A. Servo regulating valve
B. Inert gas supply. Helium, N_2 or CO_2
C. Control unit regulates rate of gas input in relation to known chamber pressure.
D. Actual pressure indicator.

2c: Vent valve thrust control
A. Control unit regulates solenoid valves
B. Vent valves increase effective throat area, reducing chamber pressure and thrust.

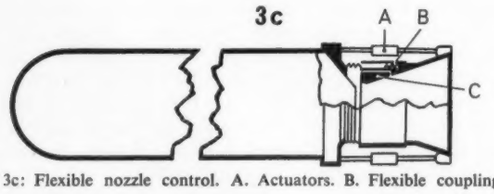
Thrust vector control



3a: Jet vane direction control. A. Mounting flange. B. Actuators. C. Carbon and ceramic vanes.



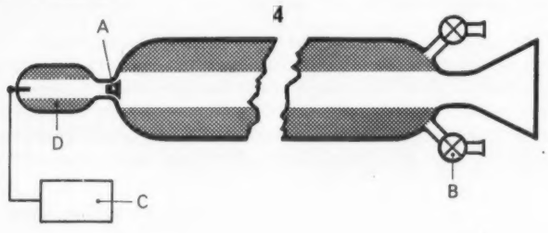
3b: Jetevator control. A. Actuators and supports. B. High temperature alloy ring control element.



3c: Flexible nozzle control. A. Actuators. B. Flexible coupling. C. Nozzle throat.

A possible reignition scheme

A. Blow-out plug. B. Vent valves to extinguish flame. C. Reignition signal unit. D. Reigniter chamber.



process has begun little can be done to change the burning rate of the solid propellant and therefore chamber pressure or thrust.

However, since there are occasionally needs for thrust variations in rocket engines, such as in manned aircraft or for such purposes as soft landings on a lunar or planetary surface, it is necessary to find ways and means of varying thrust. This problem is perhaps the most difficult one to overcome, but it cannot be ignored if the solid wishes to be competitive with liquids in the critical functions mentioned above. Several schemes are possible for use with solids, as shown in figures 2a, b, c. Of these schemes, the application of sound for burning rate control seems technically the least feasible and practical at this time; however, it is a way of directly influencing the combustion process without detracting from combustion efficiency too much. The bleeding of inert gas is however a much simpler scheme and should be more quickly developed; yet the inert gas does reduce combustion efficiency at lower-than-designed thrust levels. The combustion efficiency of the rocket may drop from 90% to 20 or 30%.

The use of vent valves is interesting because of the relative simplicity of the system—only heat resistant valves are needed. The problems are (a) finding a valve that will permit variations in port openings without gumming or caking with solid particles and without warping at the 4000° Fahrenheit temperature; and (b) obtaining symmetrical venting so that no thrust misalignment occurs. It is possible theoretically to mechanically choke or throttle the rocket's throat and thus vary the chamber pressure. But in a solid, the grain burning rate would *also* have to be varied concurrently. This scheme is almost impossible.

3. Thrust Vector Control

This system is farthest advanced in development. Mechanical devices for changing the thrust vector and therefore the direction of the flight of the rocket vehicle were used as far back as World War II by the German rocket engineers. In figure 3 are shown three major mechanical means of vector or direction control which are feasible and which have been publicly discussed. Of these, the use of jet vanes is the best developed and oldest, while the "jetevator" is fairly new. These two schemes can be applied to any given solid rocket without modification of nozzle or case and require only the mounting of such elements as actuators and support rings.

However, the use of the swivel or flexible nozzle does require a complete new design of the rocket aft end and throat and nozzle joints. Considerable difficulty in sealing the hot gas flow can occur; this scheme requires rather powerful actuating forces to move the nozzle through the usual control angle of about three to five degrees. It has the virtue of not introducing any protuberance into the exhaust gas stream and of giving the most positive control for a given deflection of an element. This method also does not have the problems of deposited coatings or alternatively erosion of jet vanes, etc., as there is no bluff body in the flame zone.

4. Reignition

Presently it does not seem feasible to reignite a solid rocket after it has shut down. It is supposed that the solid desired for this maneuver would burn only *part* of its propellant and then some quenching means, similar to the thrust level control discussed above, would extinguish the flame. Then, by some means of command, the remaining solid propellant would be reignited at least once, with combustion proceeding to completion. An analysis of the situation shows that reignition problems are tremendous when the combustion is quenched by inert gas (instead of just modified as in thrust control), or if gases are vented sideways until combustion ceases. Remaining in the rocket case is a half burned mass of propellant with charred surfaces and with no internal ignitor left. It is therefore necessary to ignite the propellant by some scheme such as the injection of a self-reacting liquid which ignites on contact with the solids. This introduces the complexities of an auxiliary liquid system. Perhaps the most feasible would seem to be the addition of one or more small auxiliary rocket chambers (see figure 4) which blast into the rocket combustion zone on a command signal and reignite the propellant. While this is simpler than a liquid auxiliary system it still requires mechanical modifications that severely tax the ingenuity of the designer. It is not likely that reignition of a solid, desirable as it may be for certain deep space missions, will be achieved in the near future.

I foresee that the "sophisticated" solid space rocket of the future will have some form of vector control with perhaps a thrust termination feature included. This would give a solid two degrees of freedom that most do not have now. It may seem more practical to add to these two features an auxiliary gas generator scheme which will trim the rocket's velocity and even its thrust on command.

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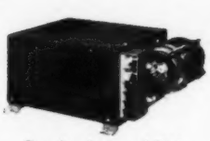
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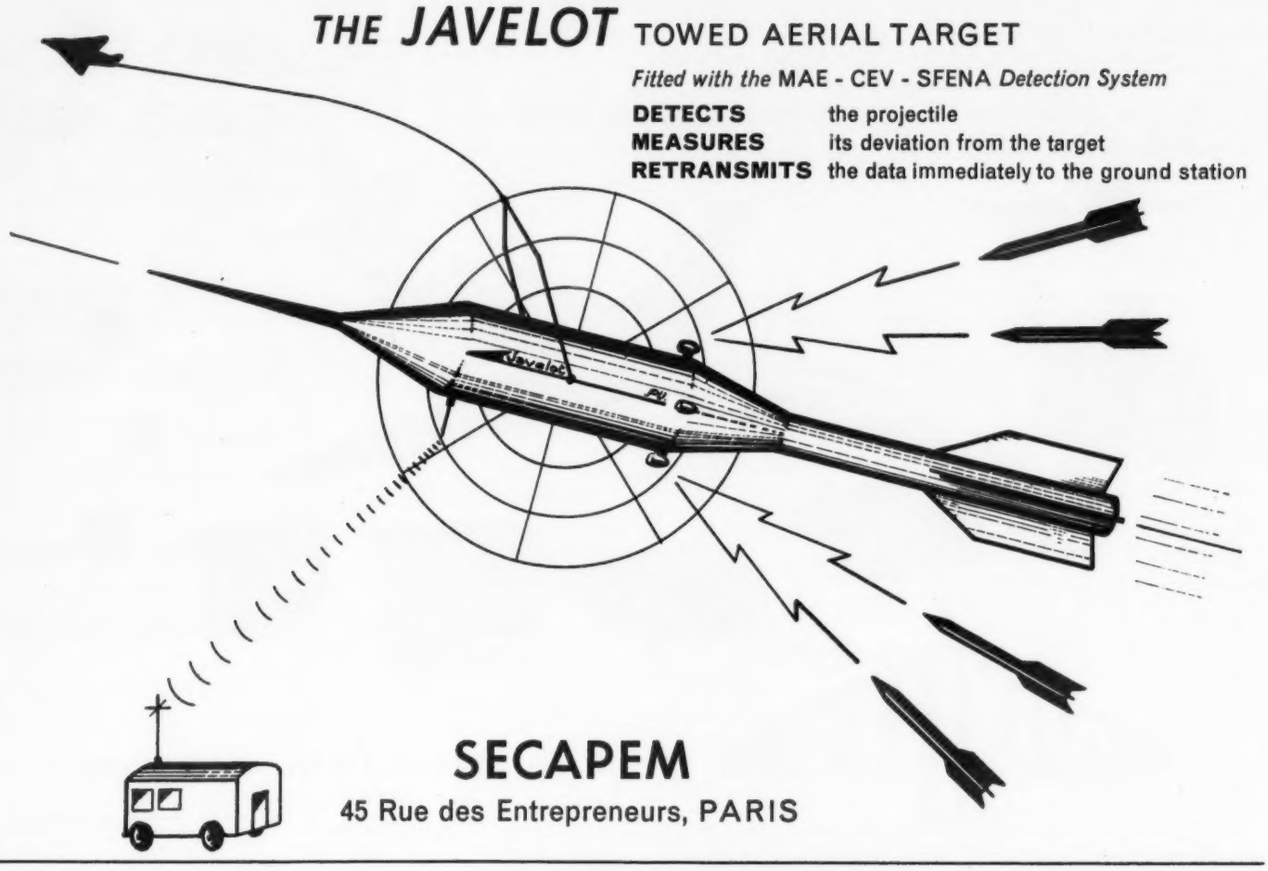

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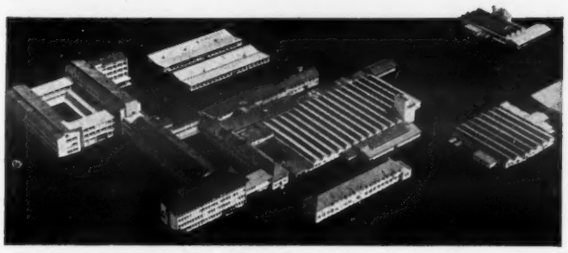

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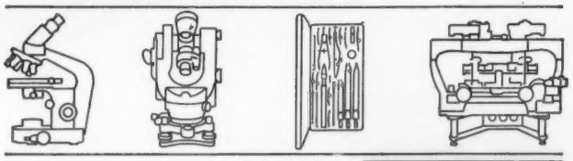

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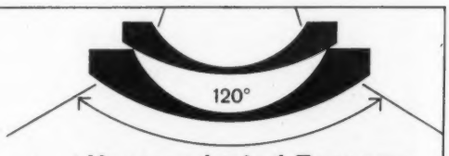

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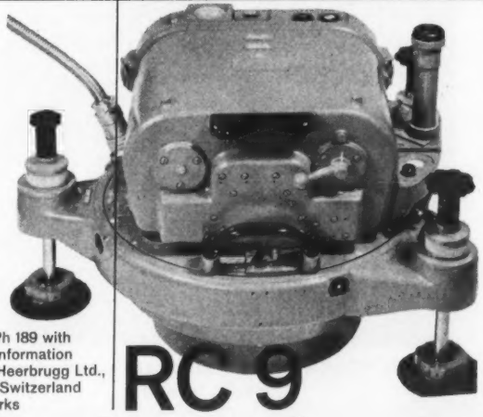

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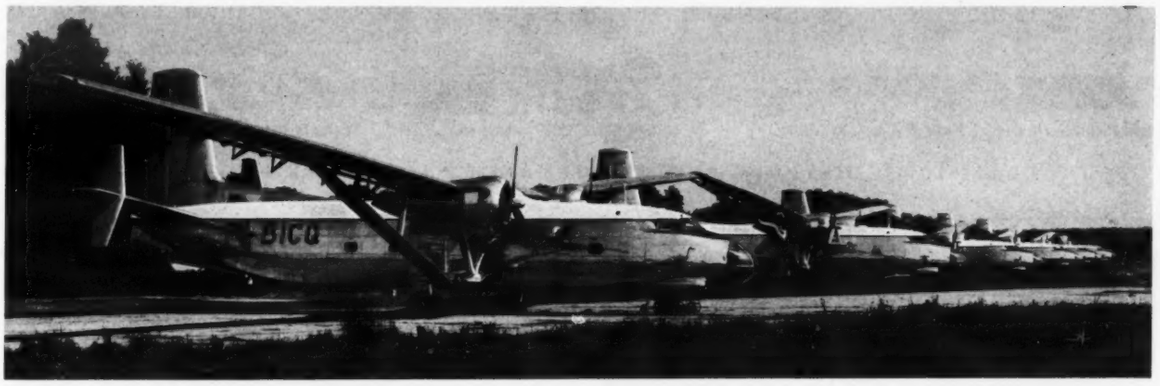

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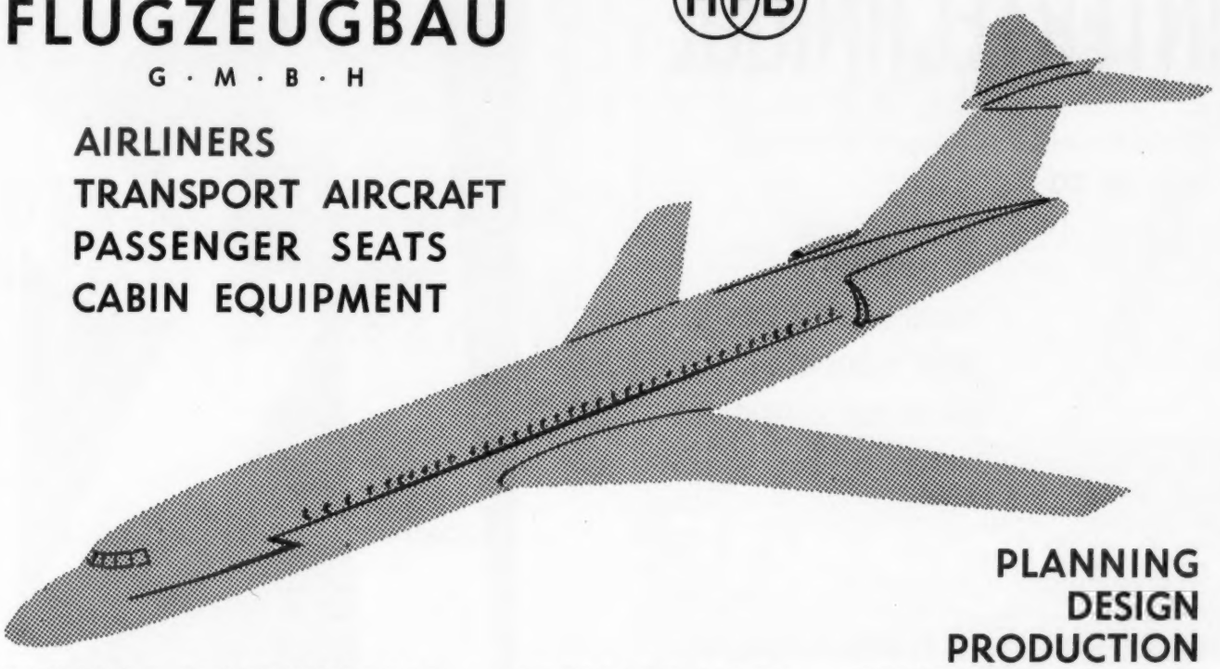

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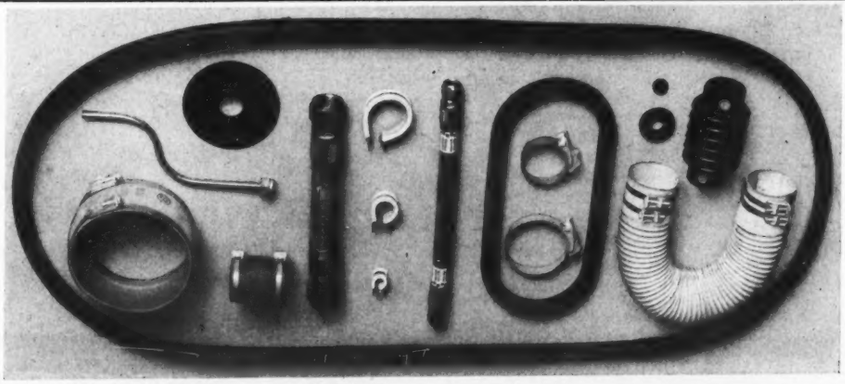

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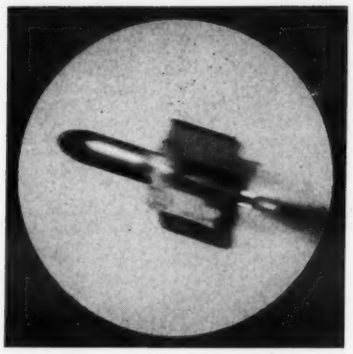

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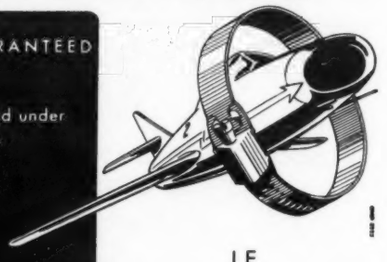

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